STUDIES ON THE ZOOPLANKTON AND HYDROLOGY OF SOUTH-EASTERN COASTAL WATERS OF TASMANIA

by

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HOBART

NOVEMBER, 1975

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THE DISTRIBUTION OF ZOOPLANKTON OFF THE EAST COAST OF TASMANIA AND THEIR VALUE AS BIOLOGICAL INDICATORS

INTRODUCTION

It is surprising that the waters off the east coast of Tasmania have not been investigated in detail, especially as they lie between the biologically and hydrologically well known areas - off New South Wales and the sub-Antarctic.

The position of the sub-tropical convergence was determined by physical and chemical methods by Deacon (1937), Rochford (1957) and Wyrtki (1960, 1962). The results of these authors were contradict~~ing~~ and were discussed by Stanton (1969) /ory who concluded that Wyrtki's (1960) suggestion that of the sub-tropical convergence **could be speculated to be correct at** least at the east coast of Tasmania.

The northern limits of the salinity of sub-Antarctic waters in the region were also in dispute amongst the authors mentioned above and it is evident that the hydrological condition off eastern Tasmania are somewhat uncertain.

The zooplankton species recorded in Section I, from the waters off the east coast consisted, apart from sub-tropical species, of a number of species endemic to sub-Antarctic and Antarctic waters. This suggests that sub-Antarctic waters have some influence in this area.

The object of this section is to examine the occurrence and distribution of zooplankton species off the east coast of Tasmania and to try and resolve the contradict~~ing~~ hydrological /ory uncertainty using the indicator species concept.

MATERIALS AND METHODS

The samples were collected by the Sea Fisheries Division, Taroona, for the "Pelagic Fish Project", by the vessel "Penghana", to study the fish eggs and larvae. Permission was kindly granted to study the zooplankton by the Head of Sea Fisheries, Tasmanian Department of Agriculture. The samples were large and furnished much material for the study of the fauna of the east coast water mass.

Field Procedure

The stations were situated in the east coast of Tasmania, between latitude 42°10', 43°20'S and longitude 148°00', 149°20'E. All these were distributed in three transects extending seaward for a distance of 30 miles. Four stations on each transect were operated about 10 miles apart, starting from a coastal station (about half a mile from shore) (Fig. 1). The stations beyond the 200 metre depth mark were considered as oceanic (Müller, 1950). A total of 10 cruises, in which 89 stations were operated, covering a period of 22 months. The month and position of stations operated are shown in Fig. 2. The initial aim was to occupy 12 stations during each cruise. However, due to weather conditions, this was not possible. The position of stations was determined by vessel's radar.

A standard plankton net with mouth area of 1.0m^2 and mesh size 330μm constructed according to D.C. Wolfe, Sea Fisheries, Tasmanian Department of Agriculture (personal communication) under the instruction of A.C. Heron, C.S.I.R.O., was used in collecting all samples. Seven minute oblique tows with 100 metres of wire released, for deep water stations and five minute oblique tows with 50 metres of wire released for shallow water stations, were

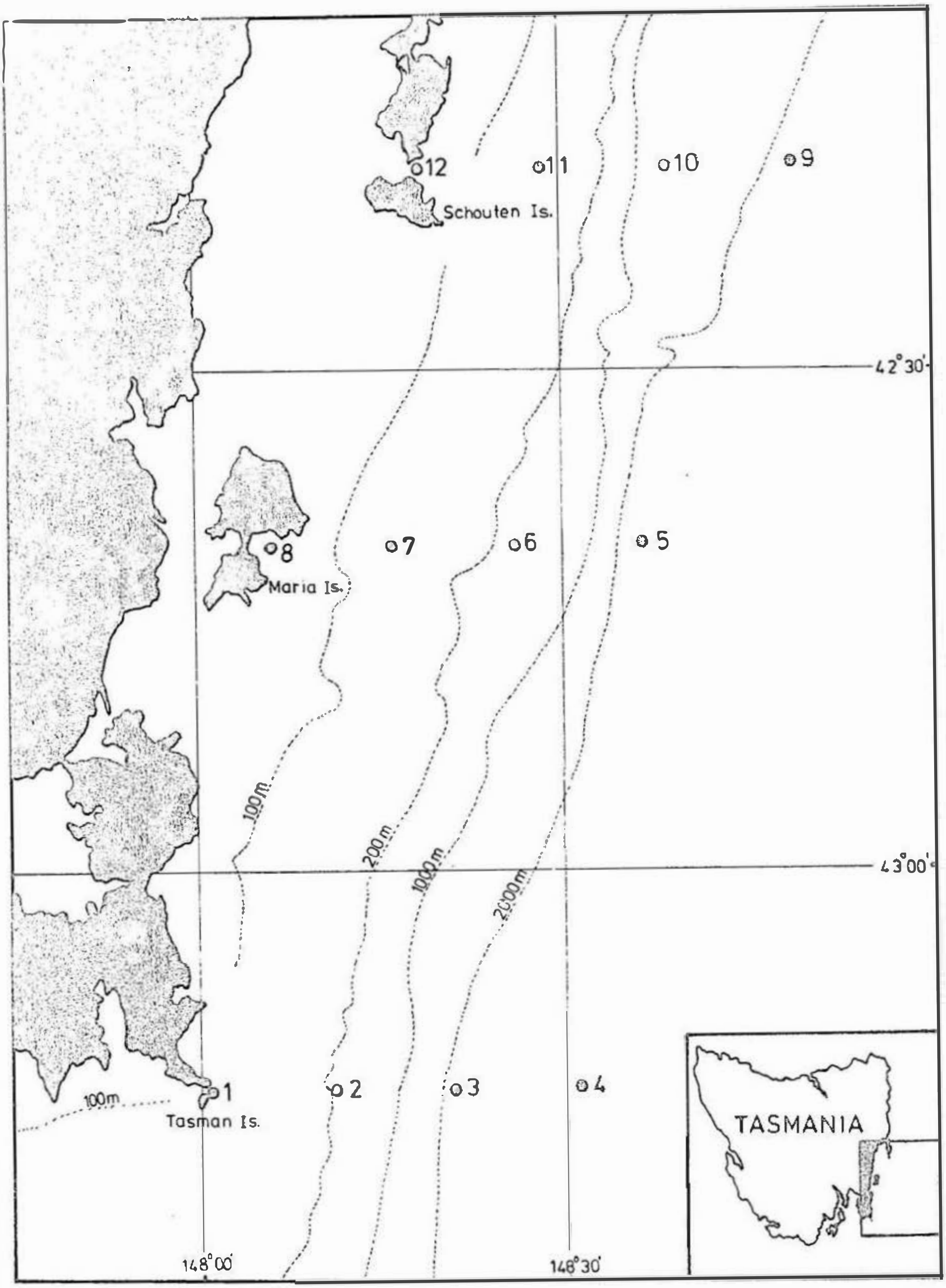

Fig. 1 Study area with basic position of stations.

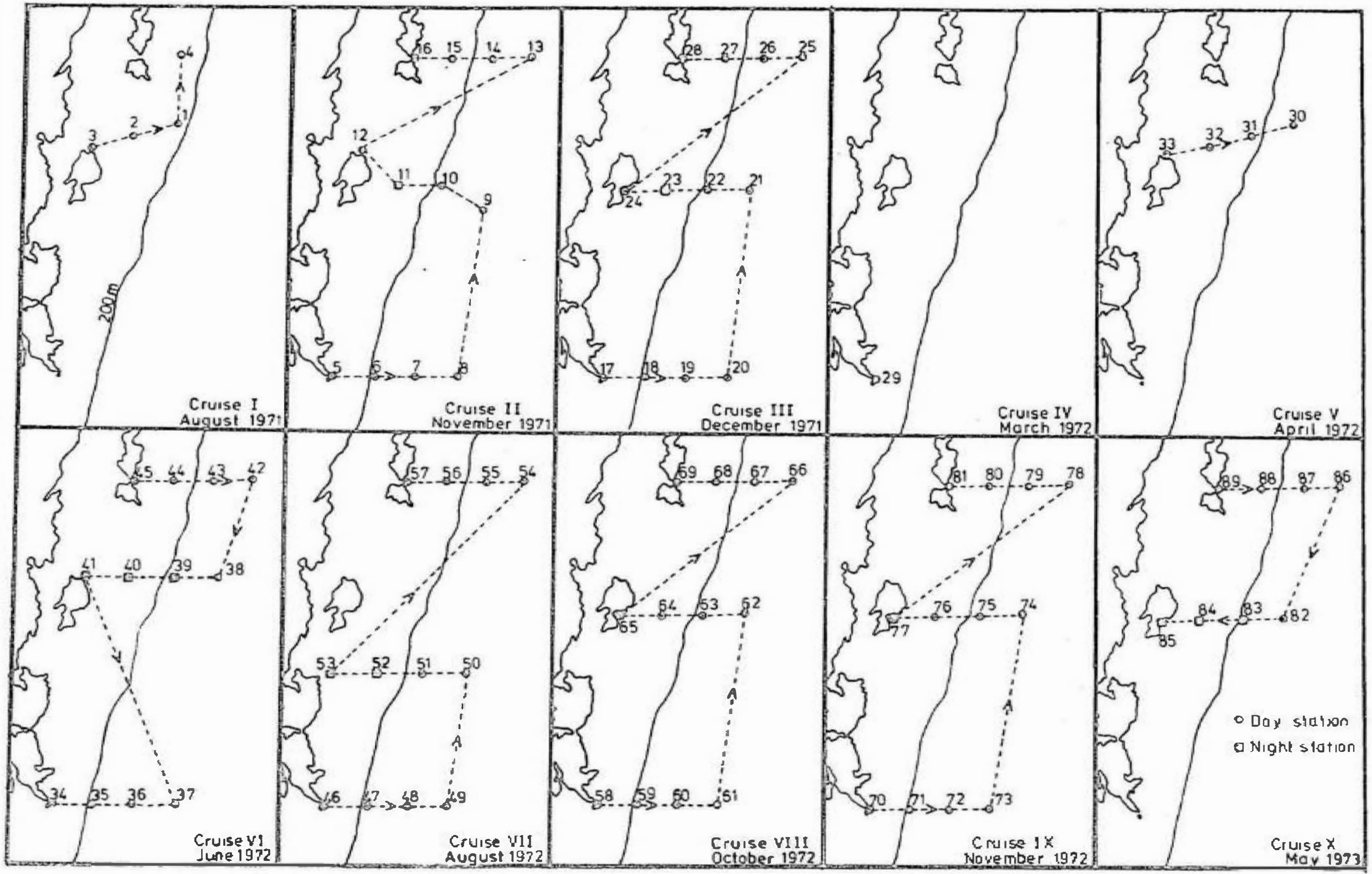

Fig. 2 The position of stations and vessels route off the east coast of Tasmania.

made. The oblique tows were made by lowering the net with a required length of cable released while the vessel was stationary. A few minutes were allowed to have the net reach the required depth. The vessel was then moved forward with the speed of about one knot as soon as the net reached the required depth and at the same time a winch was used to pull the net up very slowly. This method of sampling would minimise the effect of duinal variation in behavior of zooplankton. The samples were preserved in approximately 5% formalin immediately after each collection.

The temperature was recorded by the vessel's "Negretti" and "Zambra" type continuous thermograph which was calibrated in Fahrenheit scale, the results were later converted into Centigrade. The temperature value for Station 29, Cruise IV, was missing.

Salinity values for Cruises I to V were not available. The stations where water samples were taken for salinity determination are shown in Figure 8. The surface water samples were taken immediately after each plankton collection and stored in narrow-necked screw-tight polyethylene bottles.

Note: Initially, only an extra plankton and water sample, at the request of the present Author, was collected from the furthest (30 miles offshore) oceanic station. However, permission was later granted to study all the samples collected and to use all the hydrological data available.

LABORATORY PROCEDURE

ZOOPLANKTON

Sub-Sampling

The sub-sampling was carried out by the Modified Whirling apparatus (Kott, 1953), which produces ten sub-samples. Before sub-sampling, all large organisms such as Salps, Ctenophores, Euphausids, etc., were removed. The whole sample was examined and the rare and less abundant species were counted. For the abundant species, for example, *Acartia clausi* and *Paracalanus parvus* in the coastal waters and *Neocalanus tonsus* and *Clausocalanus ingens* in the oceanic waters, usually one tenth of the sample by volume was counted and the number for the whole sample was estimated. To decide what fraction of the sample should be counted, about one tenth or one twenty-fifth of the sample by volume, depending on the size of the sample, was extracted using a pipette and counted and the total number estimated. If the number exceeded 100 and was less than 10,000 in the whole sample, one tenth of the sample was counted. If the number exceeded 10,000, one twenty-fifth of the sample was counted.

Counting

Counting was done by using the modified counting disc and apparatus set up as mentioned below.

Apparatus setup (Fig. 3)

The apparatus setup consisted of these units - a binocular dissecting microscope, a modified counting disc and an adjustable base for the counting disc.

Description

Modified Counting Disc (Figs. 5 & 6)

The structure and dimensions are based on the counting tray (Russell and Coleman, 1931), (Wickstead, 1965) and the counting disc (Tranter, personal communication).

A transparent "Perspex" sheet which has the thickness of 13mm. is used in constructing the counting disc. There are two grooves, the outer groove (G.1) and the inner groove (G.2). These grooves are semi-divided by the septa S1, S1a and S2 into four sectors. The septum (S1) acts as an obstacle to prevent the plankton sample to be studied, from circulating in the grooves while studying. The septum (S1a) totally closed the groove (G.2), however, it does not necessarily have to be closed and could be semi-closed as septum (S1). The septum (S2) half closed the grooves so that the plankton sample could be poured off after the sample had been studied. The area "O" is the common outlet for both grooves.

The dimension of the Modified counting disc.

Diameter (outer)	215mm
Thickness of the perspex	13mm
Depth of the grooves (G.1 and G.2)	10mm
Outer groove (G.1) width	11mm
Inner groove (G.2) width	17mm
The height of Septum (S1)	2.5mm
The height of Septum (S1a)	10.0mm
The height of Septum (S2)	5.0mm

Adjustable Base (Fig. 4)

The base consisted of two parts, the main body (A) and the moveable base (B). The main body is screwed on to the base of the disssecting microscope. The moveable base is fixed

Fig. 3 – The apparatus setup.

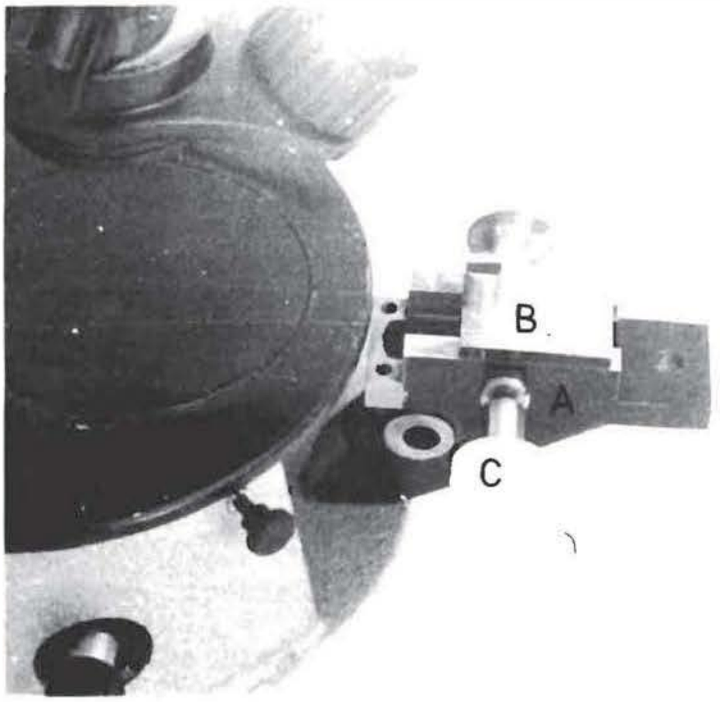

Fig. 4- Adjustable base.

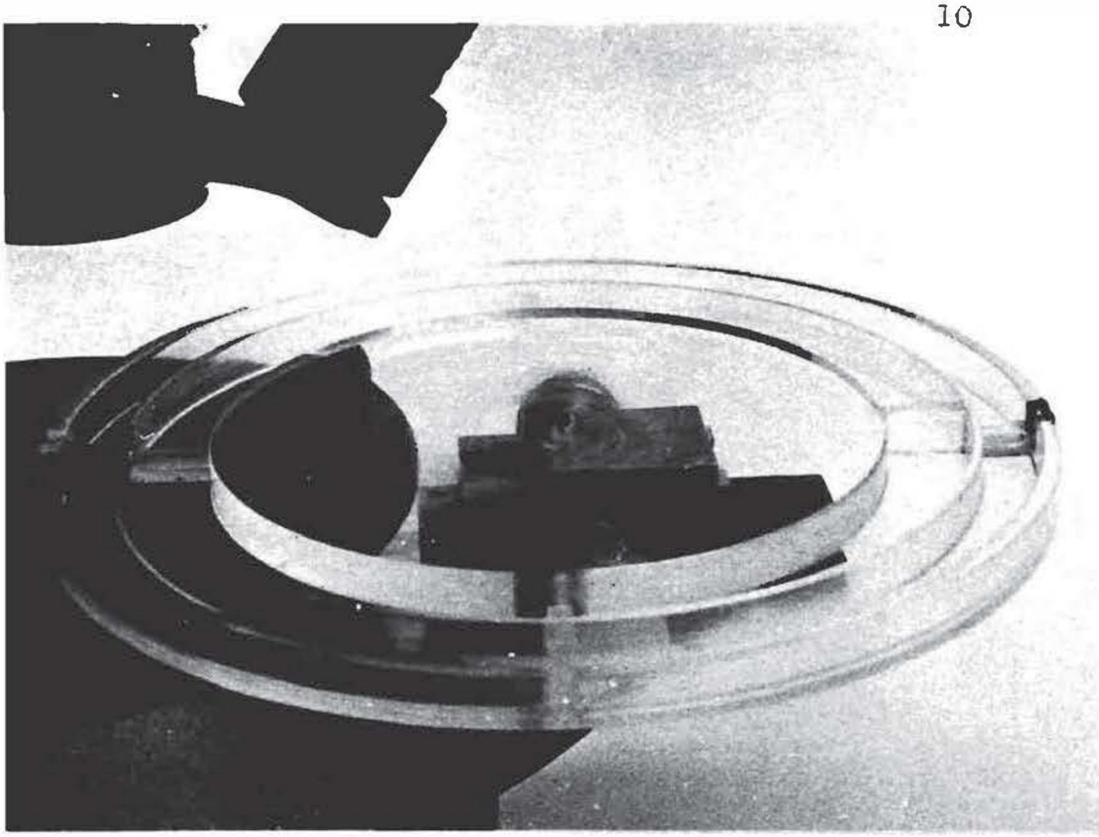

Fig. 5 Counting disk mounted on an adjustable base

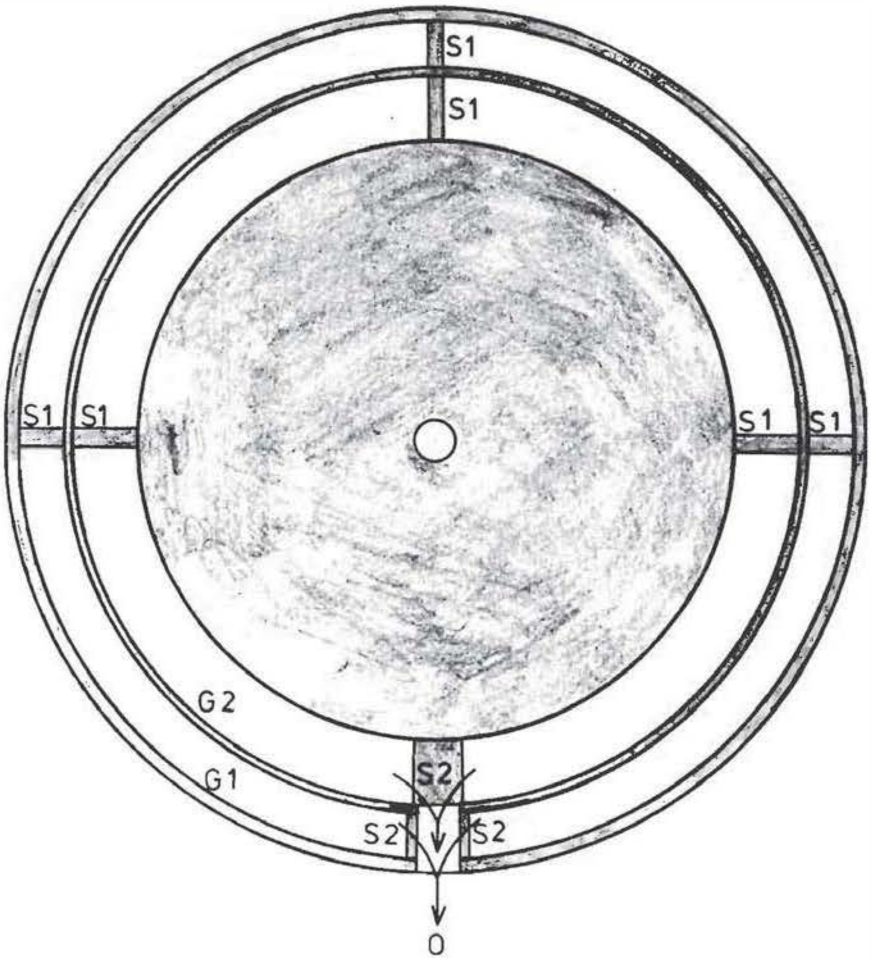

Fig. 6 Counting disk, as seen from above

on to the main body so that it can be adjusted forward and backward by the knob (C).

Use of the Apparatus

The counting disc is mounted on the moveable base and the zooplankton sample is poured into the grooves by means of a pipette. The plankton sample should just cover the septum S1 or just above or below the septum S1 level, depending on the size of the plankton and the purpose of the study. By using the adjusting knob, the groove to be studied can be adjusted.

For the grooves G.1 and G.2, the magnification of X16 and X12.5 is used respectively. Large zooplankton ($>$ 1.5mm) can be readily recognised with the magnification of X12.5, whereas the smaller zooplankton ($<$ 1.5mm) and the copepodite stages, the magnification of X16 is found to be sufficient. The animals are counted with the aid of a needle as the eye travelled along the groove.

After counting the sample, the counting disc is removed from its base. The disc is tilted with the outlet "O" part down and the sample is washed down with the aid of some 5% formalin from a pipette, poured out through the outlet "O" (indicated by arrows).

Note: The groove widths of the counting disc were specially designed for the microscope used in the present study.

Hydrology

Salinity

An Inductive Salinometer was used to determine Salinity. The apparatus was calibrated before each batch of determinations, using Copenhagen Standard Sea Water. The Inductive Salinometer has an accuracy of approximately 0.003 parts per milli (Brown and Hamon, 1961).

/m

THE ENVIRONMENT

Temperature and Salinity

Figures 7 and 8 show the distribution of surface temperature and surface salinity during the 10 cruises. During Cruise I where a few coastal stations were operated, the temperature was almost isothermal, the nearshore station having a lower temperature. In Cruise II, the temperature of coastal water was warmer than Cruise I, the isotherms of the oceanic water being roughly parallel to the coastlines. The 13°C surface isotherm was between 100m and 200m depth mark. The temperature distribution during Cruise III was similar to that of Cruise II. However, the 13°C isotherm was closer to shore, on the 100m depth mark. There seemed to be renewed warmer (14°C) isotherm oceanic offshore water parallel to the 13°C isothermal line. In the southern transect at the position of the 200m depth mark a tongue of low temperature water was also found. During Cruise V, warm (16°C) oceanic water was recorded.

The temperature recorded during Cruise VI was almost isothermal in oceanic waters, but the oceanic water was warmer than the coastal water. The 14°C isotherm was close to the coast (about the position of the 100m depth mark) at the middle and northern transect area, but further (200m depth mark) away from the coast at the southern transect. The salinity data available, showed that 35.8‰ oceanic water appeared to follow the temperature distribution. During Cruise VII, the water mass encountered was totally different from that of Cruise VI. A low temperature of between 11.7°C and 12.2°C was recorded throughout the area. The salinity found was also low - between 35.11 and 35.14‰ . A total change of water mass during the cruise from the previous cruise (Cruise VI) was obvious.

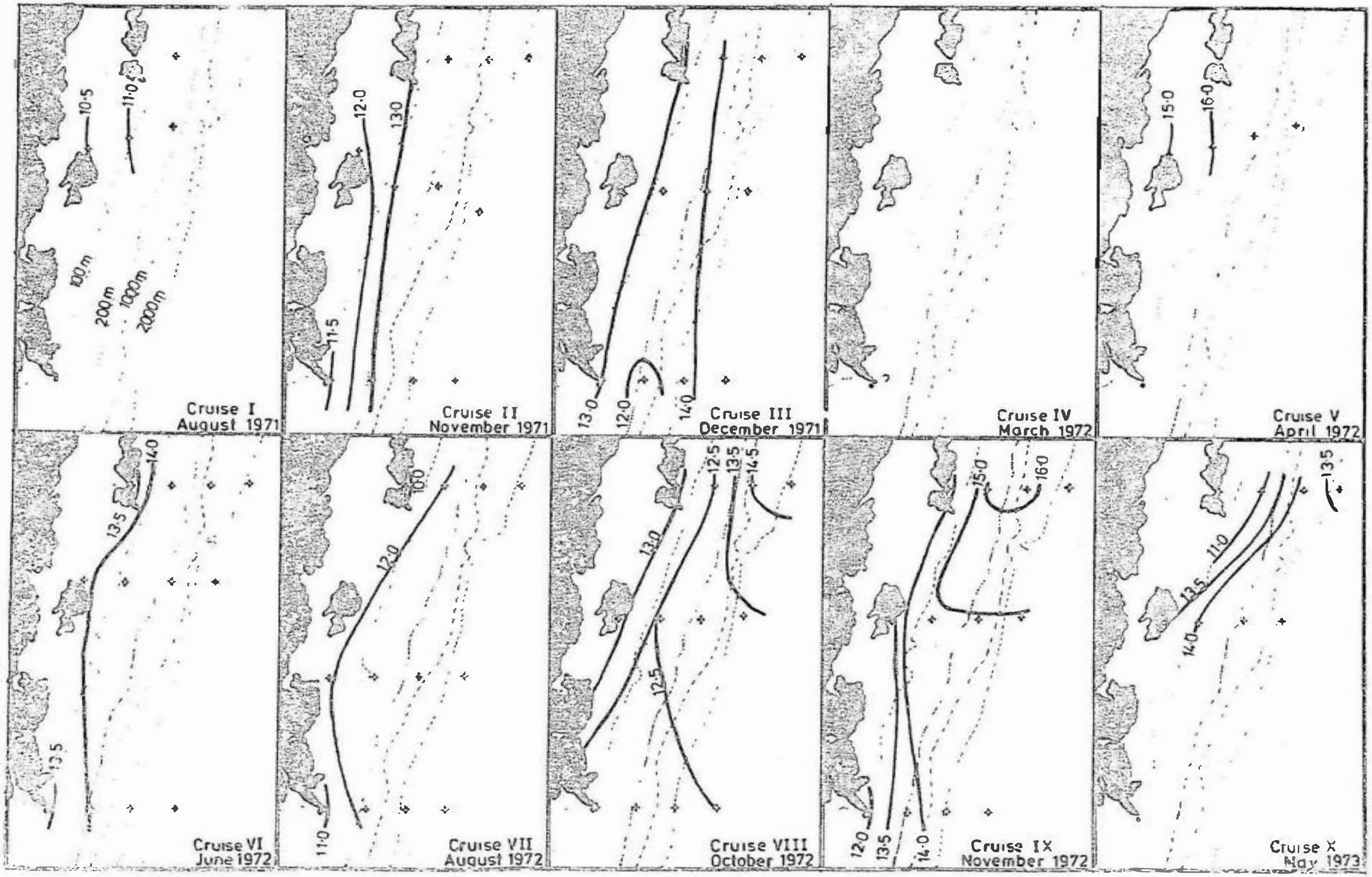

Fig. 7 Surface temperature (°C), Cruises I - X (+ = Stations where temperature values were available)

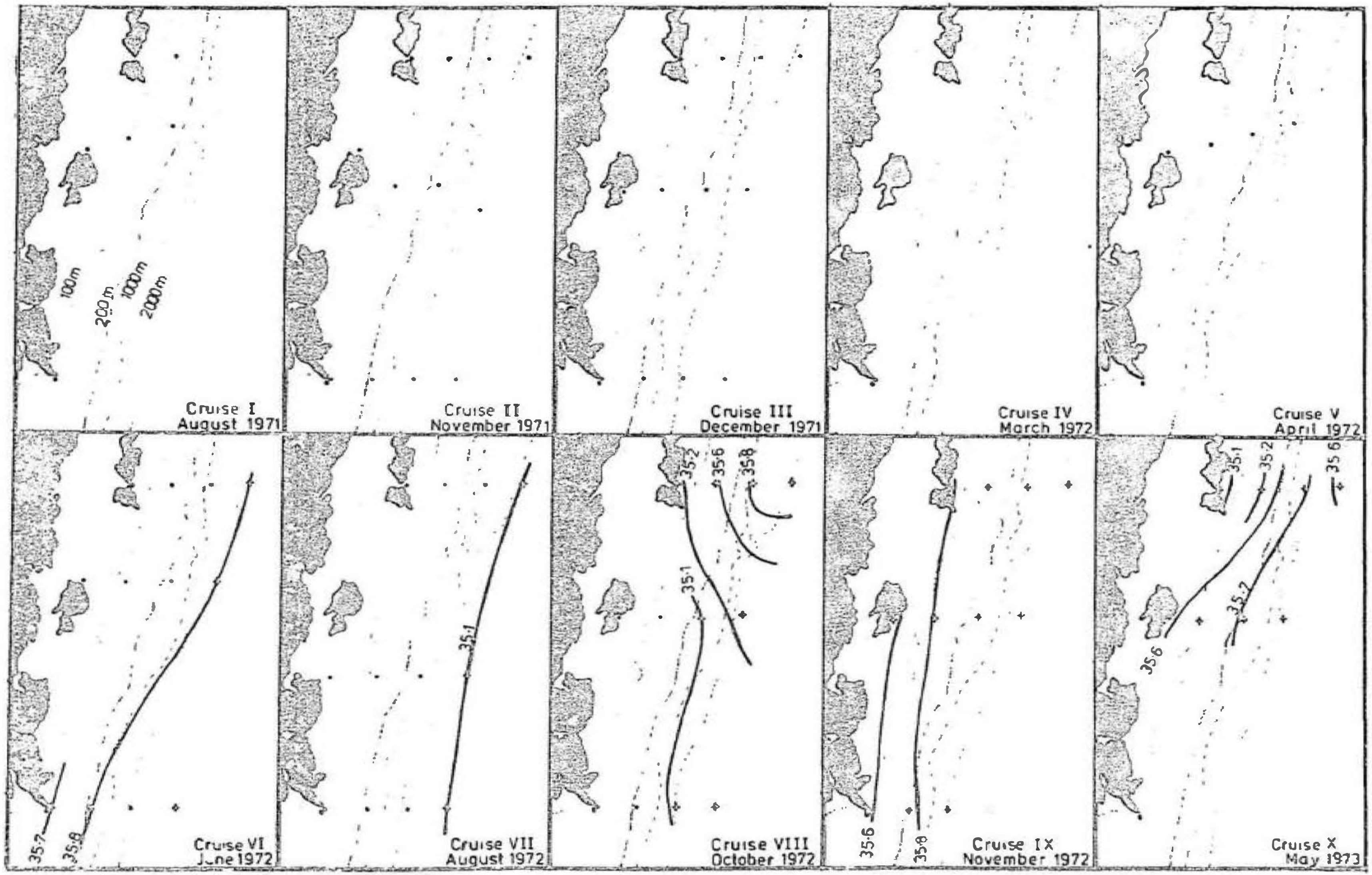

Fig. 8 Surface salinities (‰), Cruises I - X (+ = Stations where salinity values were available).

The most interesting temperature and salinity distribution was encountered during Cruise VIII. A strong gradient of both temperature and salinity was found in the oceanic waters between the northern and southern transect station. The temperature ranged from 12.2^{o}C in the southern transect to 14.4^{o}C in the northern transect stations. Similarly, the salinity ranged from 35.1‰ to 35.8‰ between southern and northern transect stations. It is evident that there were two types of water masses during the cruise. These physical and chemical findings were supported by the zooplankton population encountered (see discussion).

During Cruise IX the invasion of warm waters from the north was apparent. The 14^{o}C isotherm was pushed into the shallow water area ($<$100m) in the middle and northern transects and deep water (1000m) in the southern transect station. The strong gradient of temperature - 14^{o}C in the southern transect and 16^{o}C in the northern transect station - was found in the oceanic waters. The 35.8‰ isohaline line was similar to that of 14^{o}C isotherm line. However, in the oceanic waters an isohaline water of about 35.8‰ was seen throughout the area.

In Cruise X the temperature followed the salinity trends where the 14^{o}C isotherm approximately coincided with 35.6‰ isohaline. An unusual lower temperature and salinity was recorded at the furthest station at the northern transect station. The temperature and salinity were lower at the coastal waters.

Generally, the temperature ranged from 11.7 to 16.1^{o}C and the salinity was from 35.11 to 35.89‰ in the oceanic waters during the 10 cruises.

Remarks

The temperature and salinity recorded during the 10 cruises were within the range recorded by Vaux (1970) during a few months between 1961 and 1965 in the vicinity off the east and northeast coast of Tasmania. The minimum temperature of 11.7°C in Cruise VII compared with the minimum of 11.4°C recorded by Vaux in October, 1962 (August data was not available.). The maximum temperature was 16.1°C, which was well within the range recorded by Vaux.

Similarly, the range of salinity (35.11‰ - 35.89‰) in the present study in the oceanic waters were within the range (35.01‰ - 35.83‰) recorded by Vaux.

Wyrtki's (1960, 1962) classification of water masses was adopted as the basis for discussion, namely, the water mass which had the temperature and salinity of 11.7 and 13.0°C and 35.11 and 35.20‰ respectively, was considered as sub-Antarctic and the temperature and salinity higher than those was considered as sub-tropical in the oceanic waters.

DISTRIBUTION OF INDIVIDUAL SPECIES OF ZOOPLANKTON

The majority of zooplankton encountered were identified to species and a systematic account is given in Section I. The total number of species found off the east coast of Tasmania is 82.

The quantitive distribution of the individual species is shown on a series of maps on which the number per seven minutes tow at each station is indicated by a series of symbols in the appropriate maps. To aid the discussion of abundance, the following series of code words are used corresponding to a scale of the number of specimens per seven minute tow.

1	-	5	=	rare
6	-	100	=	common
101	-	1000	=	very common
1000			=	abundant

COPEPODA

CALANOIDA

CALANIDAE

Calanus australis

Occurrence.............. Fig. 9.

It was a widespread and usually common to abundant species taken in almost all the stations operated. Kott (1957) and Dall (1957a) regarded it as an indicator of southern coastal waters of New South Wales. Similarly, Jillett (1971) found it to be coastal in nature. However, Brodsky (1961, 1967) and Roberts (1972) considered it to be an oceanic species. It appeared in the present study to be more characteristic of coastal

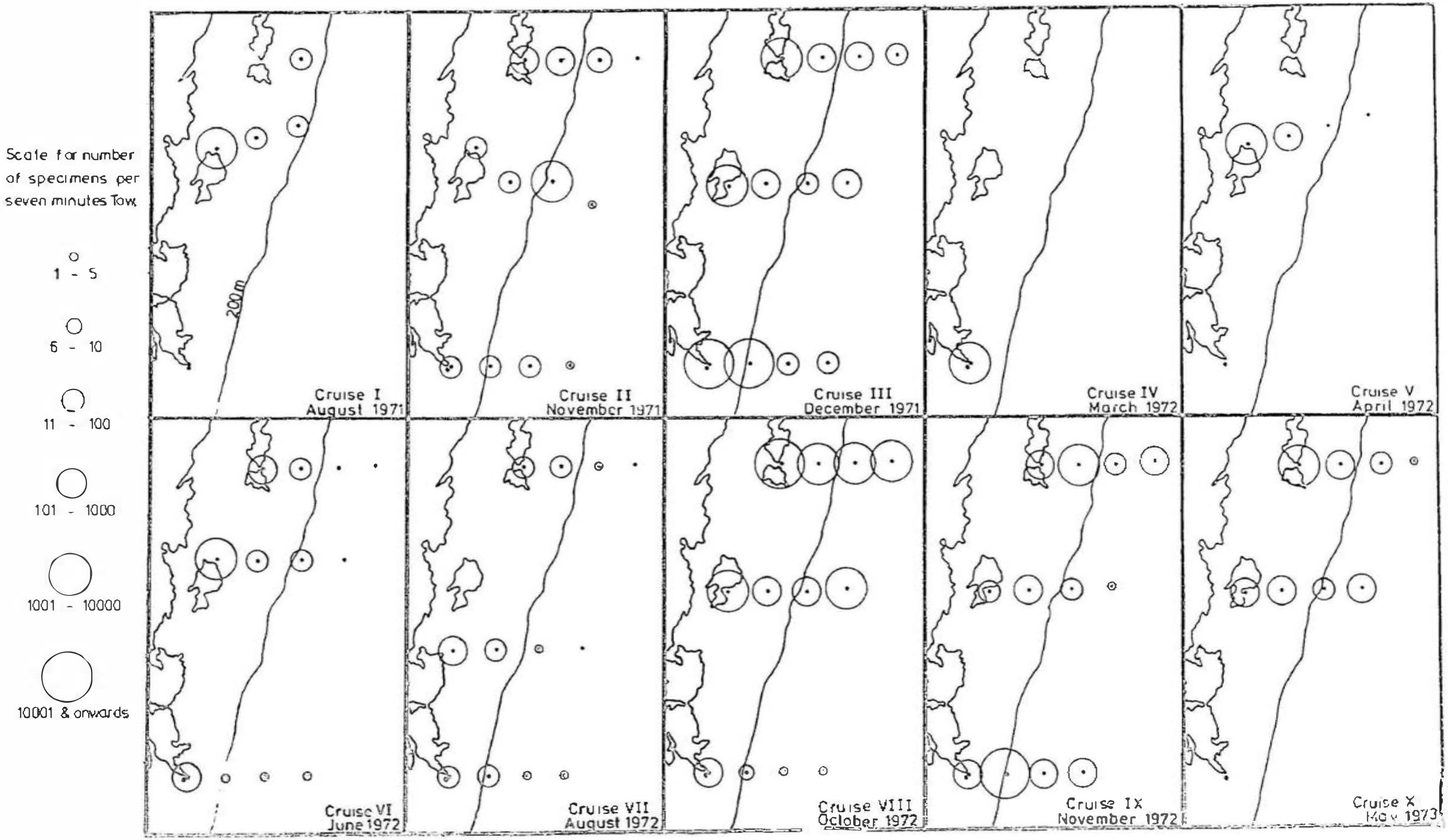

Fig. 9 Distribution of Calanus australis, Cruises I - X.

waters as the number taken was greater at the coastal stations than at the oceanic stations. As such, unless found in large numbers, its value as an indicator of such water is not reliable.

Calanus minor

Occurrence............... Fig. 10.

It was taken in all cruises. A common species in a number of stations occupied during Cruise I. In Cruise II and II it was found only in a few stations as a rare constituent. From Cruise IV to Cruise VI it occurred frequently, usually as a common constituent in both coastal and oceanic stations. During Cruise VII it appeared to be restricted to coastal waters. It was a common species in the northern transect oceanic stations during Cruise VIII In Cruise IX and X it was widespread in occurrence, as a rare to common constituent.

It has a worldwide distributional record, as far south as the Ross Sea, Antarctic, where a damaged specimen was recorded by Bradford (1971). Generally, it is a sub-tropical, tropical warm water species. Dakin and Colefax (1940) and Dall (1957a, 1958) found it to be common in the south east coastal waters of Australia. Kott (1957) considered it as an indicator of surface offshore Tasmanian waters. In the present study it was found to be usually associated with warm water species and appeared to prefer warm, high salinity, sub-tropical water (Fig. 11).

Calanoides carinatus

Occurrence.............. Fig. 10

The occurrence of this species was found to be restricted from late spring to early summer, when the number encountered was mainly very common to abundant. During the remaining cruises

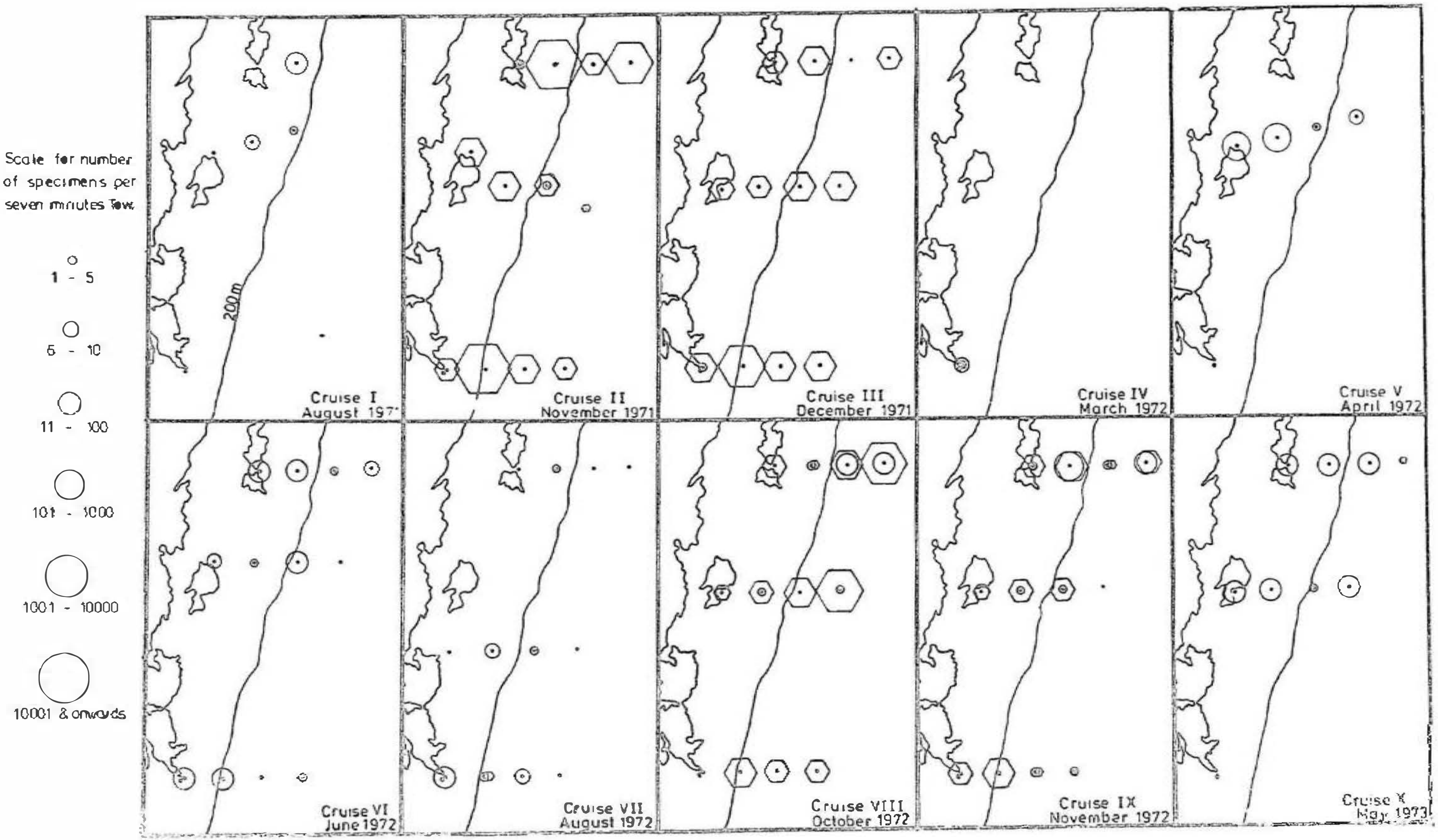

Fig. 1 . Distribution of Calanus minor (○) and Calanoides carinatus (⬡), Cruises I - X.

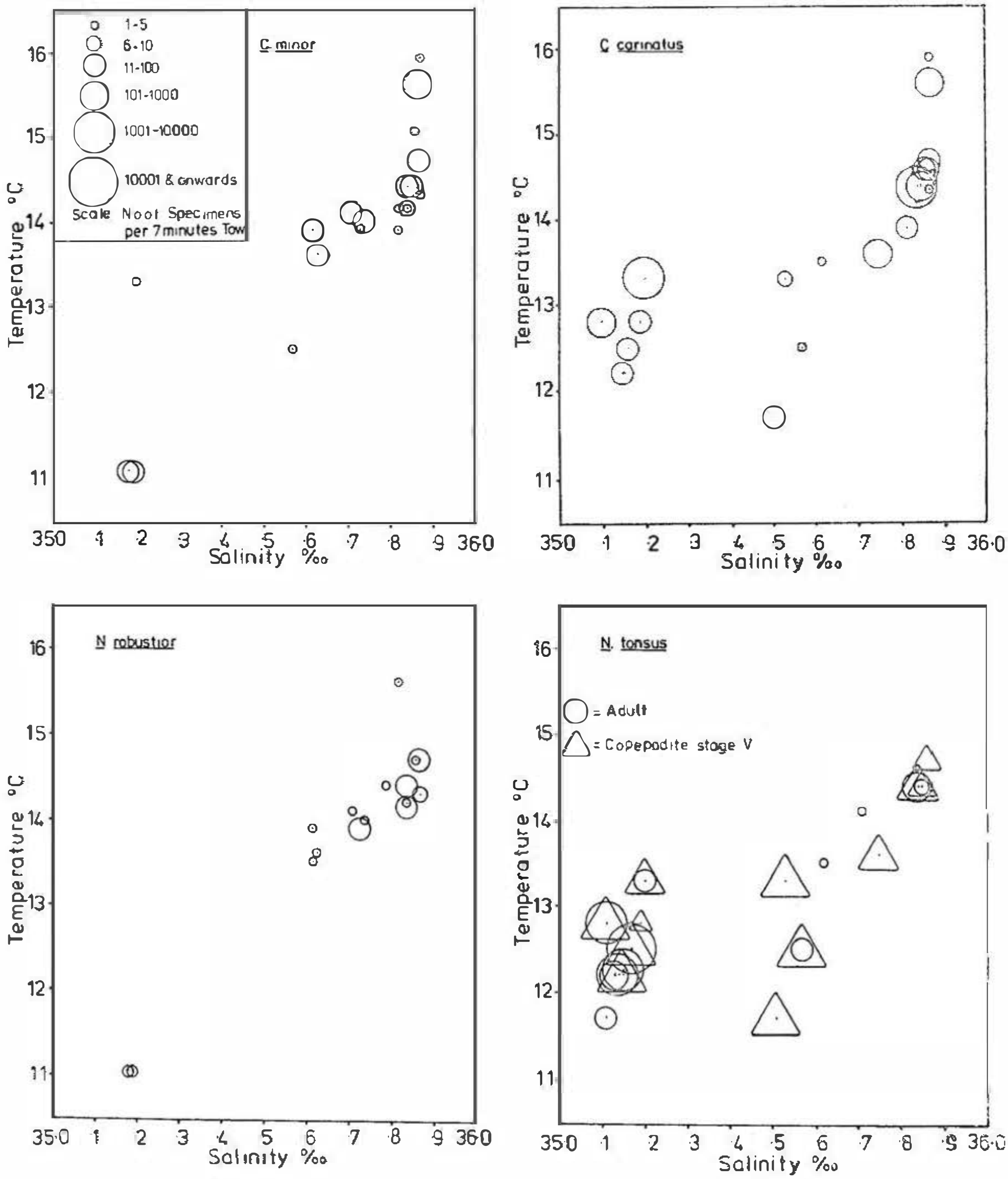

FIG. 11 TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR CALANUS MINOR, CALANOIDES CARINATUS, NEOCALANUS ROBUSTIOR AND NEOCALANUS TONSUS.

it occurred sporadically as a rare constituent. The specimens taken in the area were mainly fifth copepodite stage and adult females.

The habitat and occurrence in the area was very similar to that of Neocalanus tonsus. However, it appeared to have a wider range of tolerance to temperature and salinity (Fig. 11). Dall (1957a and b) also reported it to be abundant in the south east coastal waters of Australia.

Mesocalanus tenuicornis

Occurrence.................. Fig. 12

The taxonomy of this species was discussed in Section I. It occurred sporadically as rare to common constituents in both coastal and oceanic waters.

Neocalanus robustior

Occurrence.................. Fig. 12

It occurred only in a few stations during Cruises I and II. During Cruise IV and V it was taken in a number of stations usually common to very common in number. It was found only in the northern transect stations during Cruises VII and VIII. It occurred frequently from rare to common costituents during Cruises IX and X.

According to Brodsky (1967) it is a tropical circumglobal species. From the available temperature and salinity values, it was found to favour warm, high salinity sub-tropical waters (Fig. 11).

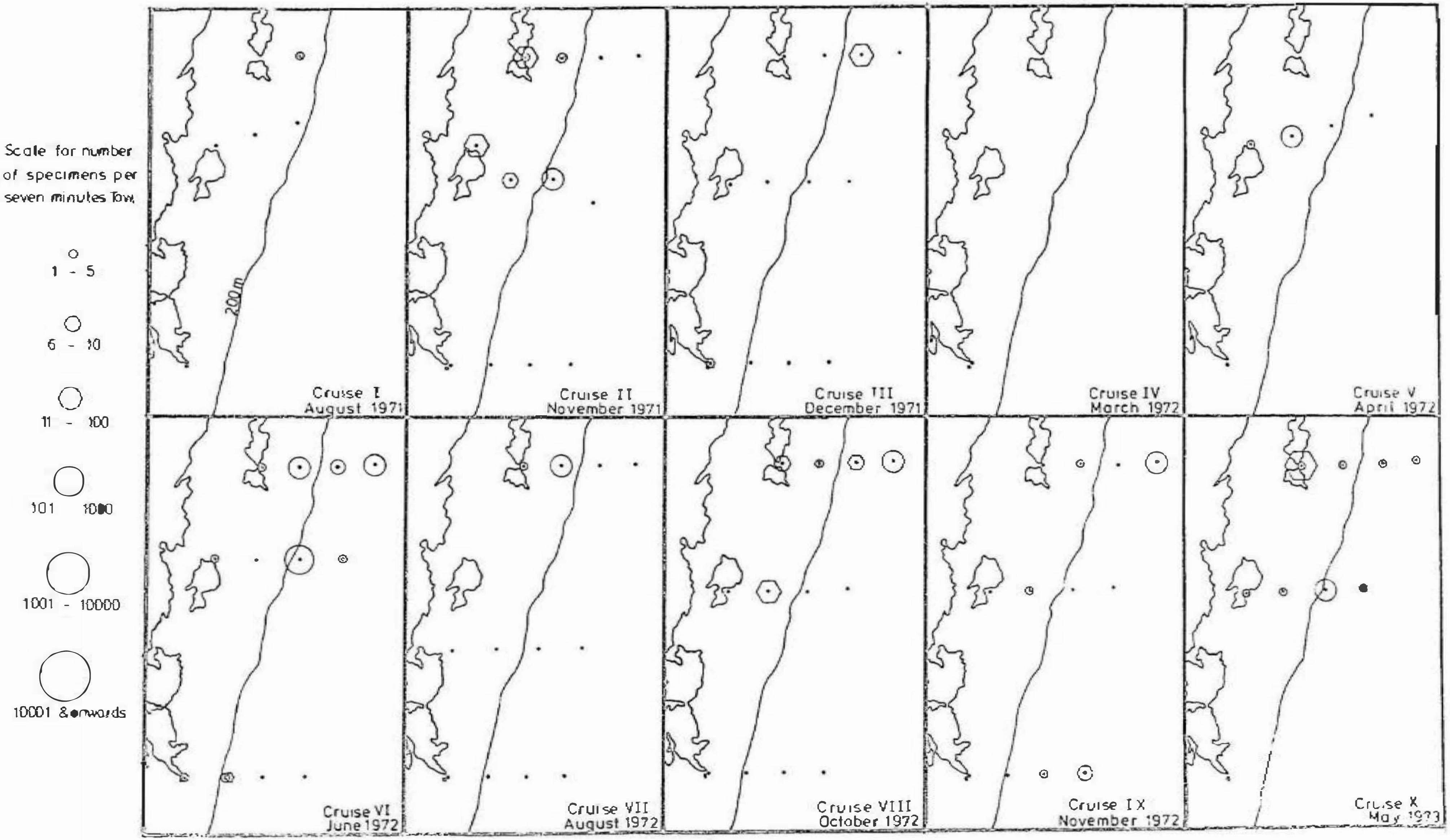

Fig. 12 Distribution of Mesocalanus tenuicornis ( ) and Neocalanus robustior ( ), Cruises I

Neocalanus tonsus

Occurrence.................. Fig. 13.

Adult and fifth copepodite stages were found in abundant numbers from late winter to early summer cruises (August to December). The adults appeared in the late winter cruises (August) in abundant numbers and the number diminished in late spring (November). The number taken was greater in the oceanic stations. A few specimens (rare constituents) were also taken at one station in Cruise VI and at two stations in Cruise X. The fifth copepodite stages were not found until mid-spring (October) cruise. They were abundant and encountered in the oceanic as well as in the coastal stations. In late spring (November) and early summer (December) cruises they were found to be restricted to the coastal waters.

Jillett (1968) found this species (adult females and fifth copepodite stages) to be abundant in the surface waters off south-east New Zealand waters from spring to early summer (September to January). His findings and the observations in the present study area appeared to be very much similar even though the salinity values of water where N. tonsus was found were much higher.

This species was recorded in the vicinity, north and east, of Tasmania by Dall (1957a, b).

According to Vervoort (1957), Brodsky (1964, 1967) and Jillett (1968), N. tonsus is a sub-antarctic planktonic copepod. The presence of it in the east coast of Tasmania in abundant numbers, no doubt indicate the presence of sub-antarctic waters. In the present study, the tolerance to temperature and salinity of fifth copepodite stages and adult females, was found to be different (Fig. 11). The fifth copepodite stage was found to

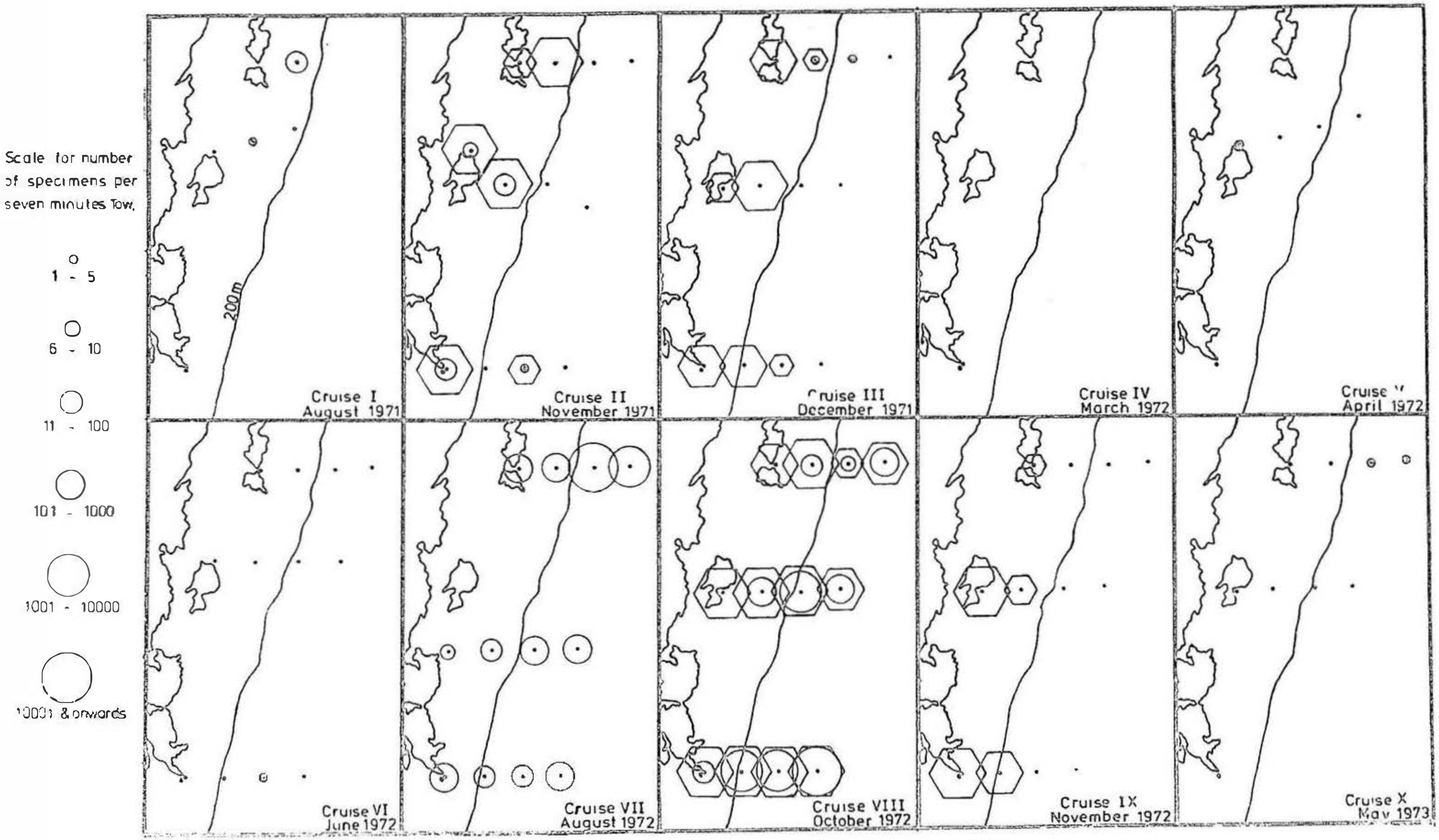

Fig. 13 Distribution of *Neocalanus tonsus* (adult = ○ , Copepodite stage V = ⬡), Cruises I - X.

have a wider range whereas the adult females appeared as expected, to prefer cold, low salinity, sub-antarctic waters.

EUCALANIDAE

Eucalanus attenuatus

Occurrence............... Fig. 14.

It occurred frequently, rare to common in the oceanic waters and rare in the coastal waters. It was taken mainly from late winter (August) to early summer (December) cruises.

Dall (1957a) reported it from the east coast of New South Wales. According to Dall (1957b) it is an abundant species in the south west Tasman water mass. From the available temperature and salinity values, it seemed to prefer warm, high salinity sub-tropical waters (Fig. 15). However, since it was not found in warm months (Autumn to early Summer cruises) the preference to a particular water mass is doubtful.

Eucalanus crassus

Occurrence............... Fig. 14.

It occurred sporadically from Cruise I to Cruise V. During Cruise VIII it was taken in the northern oceanic station as a common constituent. It was found in both coastal as well as oceanic stations from rare to common constituent in Cruise X. It occurred only in two oceanic stations in rare numbers during Cruise X.

Dakin and Colefax (1940), Kott (1957) and Dall (1957a) found this species to be very common in the northern coastal waters off New South Wales. The temperature-salinity plankton diagram (Fig. 15) shows the narrow range of conditions (warm - high salinity) under which it exists. The presence of this

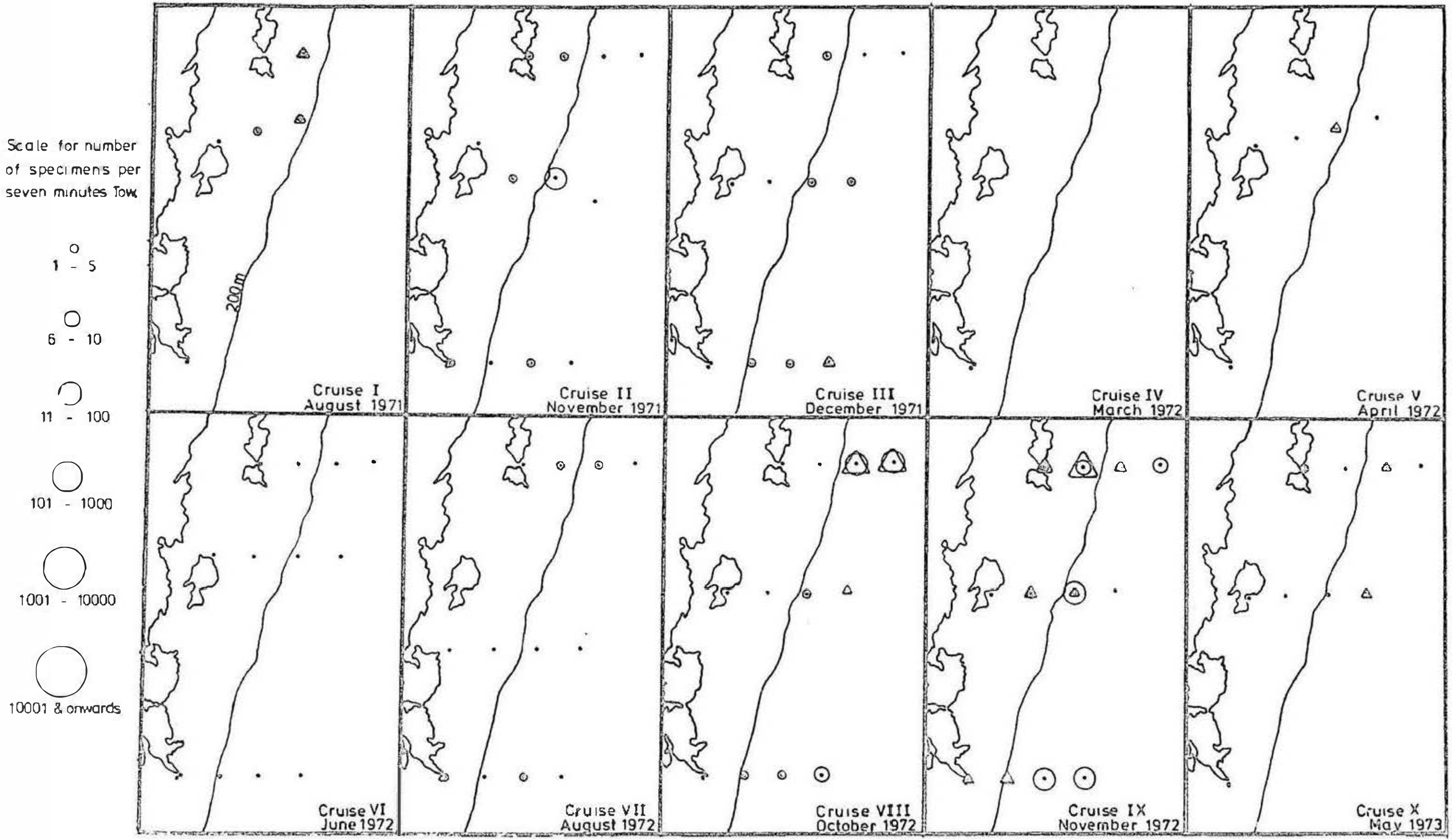

Fig. 14 Distribution of <u>Eucalanus attenuatus</u> (○) and <u>Eucalanus crassus</u> (△), Cruises I - X.

species in the study area indicates the presence of northern coastal waters off New South Wales.

Eucalanus elongatus

Occurrence................. Fig. 16.

Apart from Cruises VI and VII, it was widespread in distribution, occurring usually as common to very common in oceanic waters. It seemed to prefer warm, high salinity sub-tropical waters (Fig. 15).

Eucalanus longiceps

Occurrence................. Fig. 17.

It occurred mainly in the oceanic waters from late winter (August) to early summer (December cruises). A large number - common to very common constituent - was taken in Cruises VIII and IX.

Bary (1959) used this species (as *E. acus*) as an "Intolerant Southern Sub-antarctic" indicator in the south eastern New Zealand waters. Vervoort (1965) found it to be very common in the surface waters of sub-antarctic. In the present study a high number was found in the cold, low salinity sub-antarctic waters and at the same time, a few specimens were also taken in warm, high salinity waters. However, temperature

lp - salinity - ~~P~~lankton diagram (Fig. 15) indicates that it preferred cold, low salinity waters.

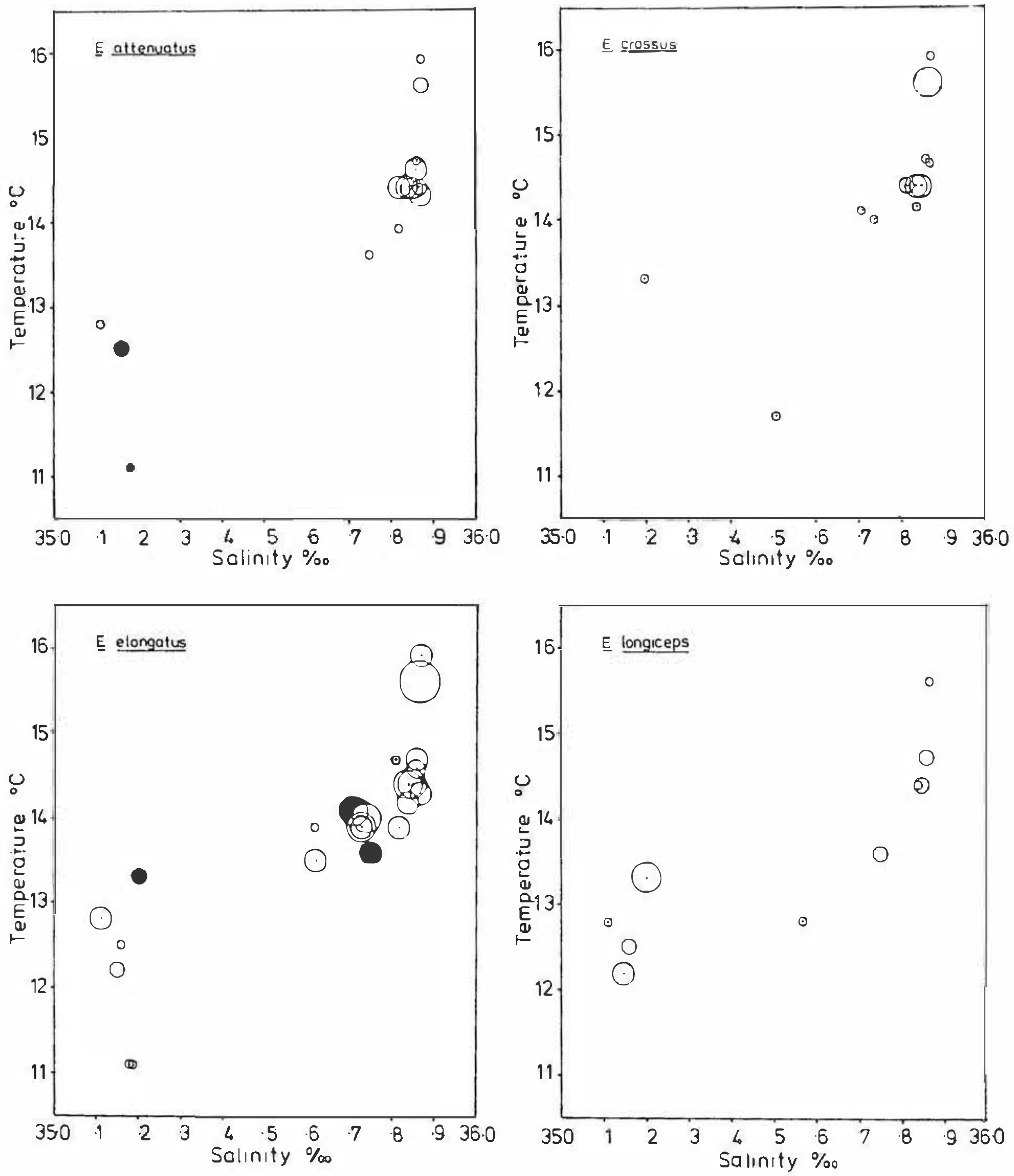

FIG. 15 TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR *EUCALANUS ATTENUATUS*, *EUCALANUS CRASSUS*, *EUCALANUS ELONGATUS* AND *EUCALANUS LONGICEPS*.

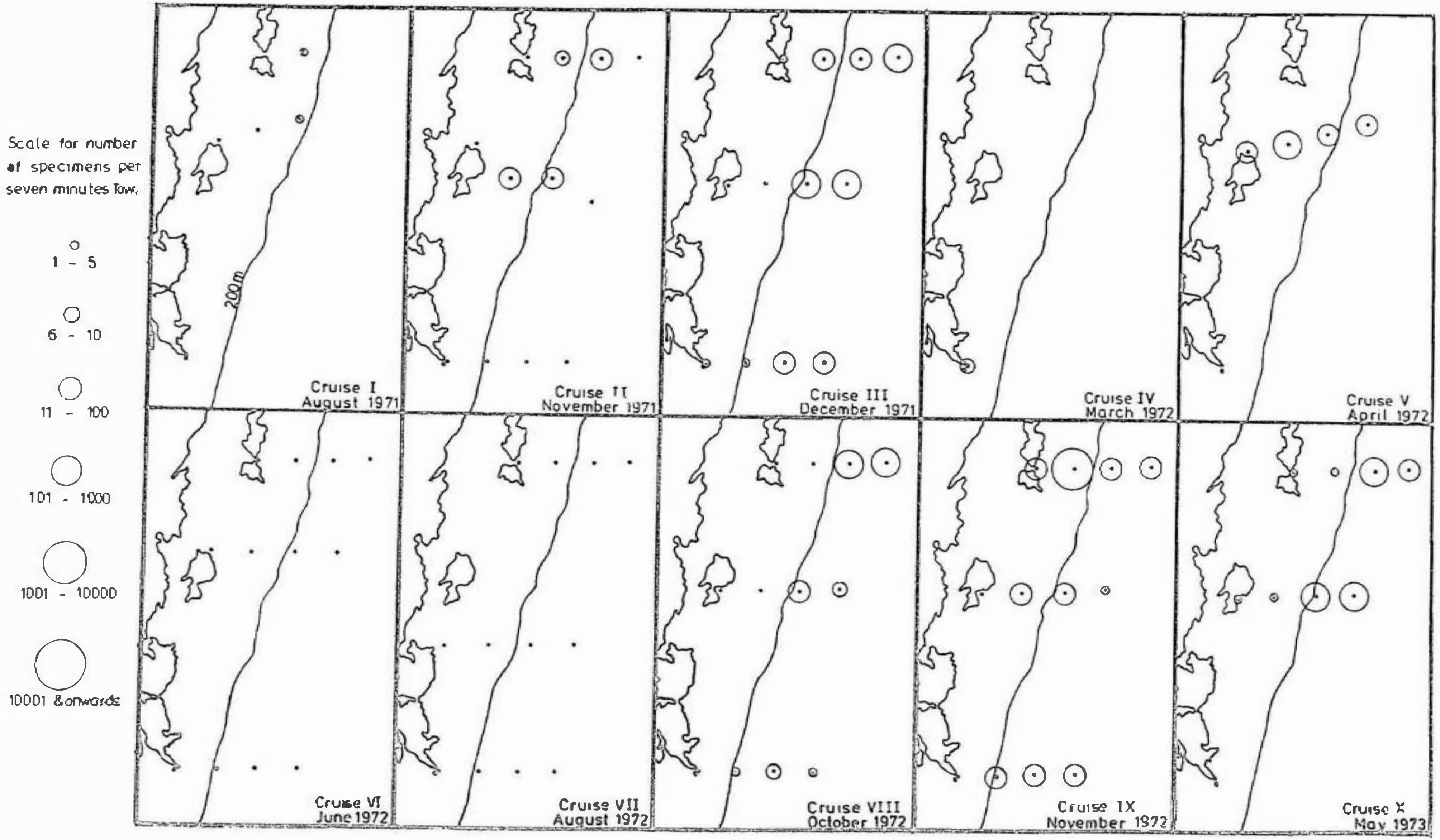

Fig. 16 Distribution of Eucalanus elongatus, Cruises I - X.

Mecynocera clausi

Occurrence............... Fig. 18.

It was a widespread species occurring in almost all the stations in common to very common constituents. The number found was comparatively low in the coastal than in oceanic waters. The wide range of tolerance to environmental conditions (Fig. 19) and its widespread distribution, makes it useless as an indicator of particular oceanic waters, but it can be regarded as a local oceanic species and as such, if found in the coastal or inshore coastal waters, would indicate the presence of oceanic elements.

Rhincalanus nasutus

Occurrence................. Fig. 17

It occurred usually common to very common in a number of oceanic stations from mid-spring (October) to early summer (December) and autumn (April and May) cruises.

Kott (1957) found it to be common in the offshore waters of northern parts of New South Wales and regarded it as an indicator of such waters if found in the southern part of the region. In the present study it was found to prefer warm, high salinity sub-tropical water (Fig. 19). The presence of this species in the study area indicates the intrusion of northern waters.

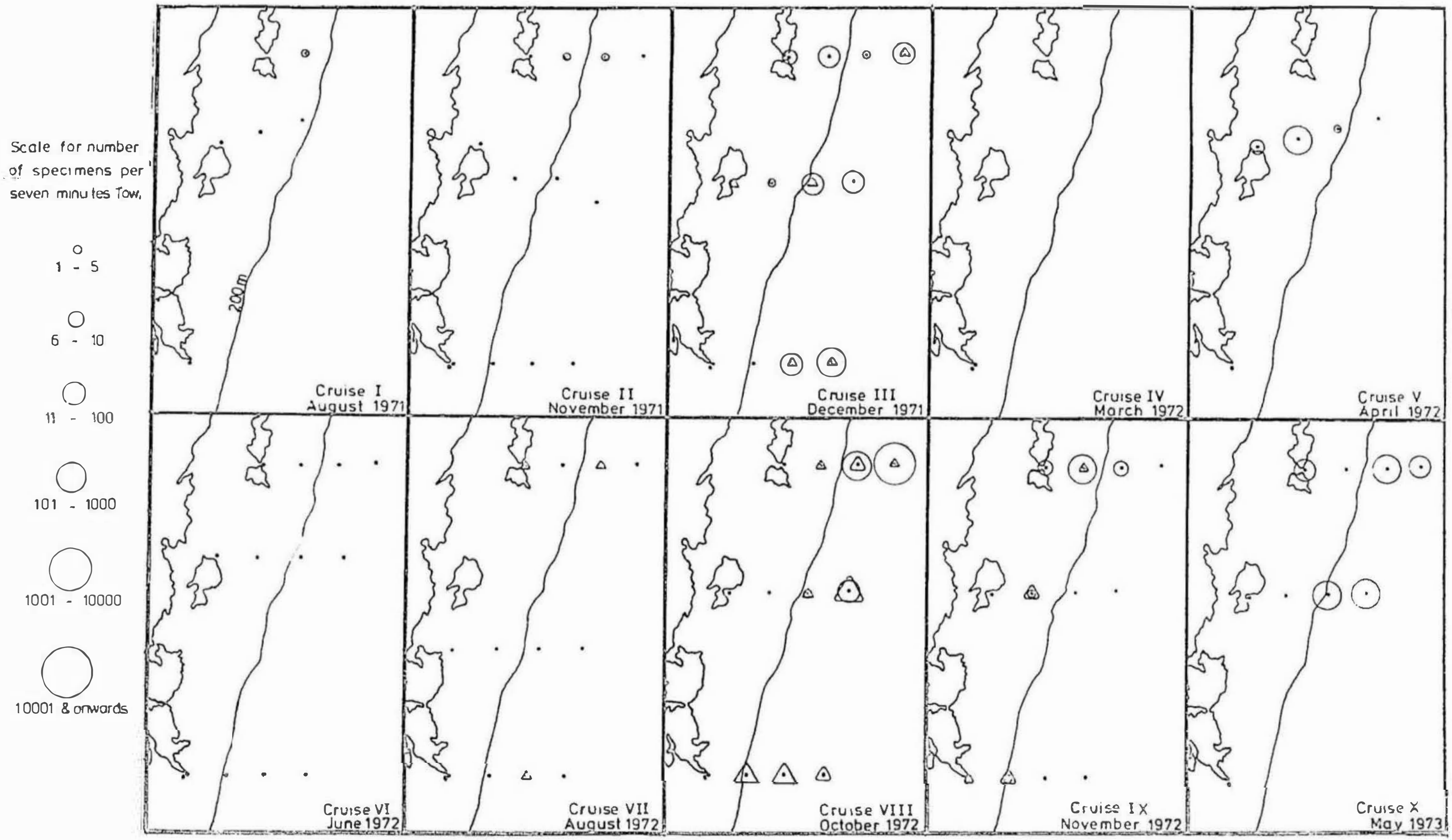

Fig. 17 Distribution of Eucalanus longiceps (△) and Rhincalanus nasutus (○), Cruises I - X.

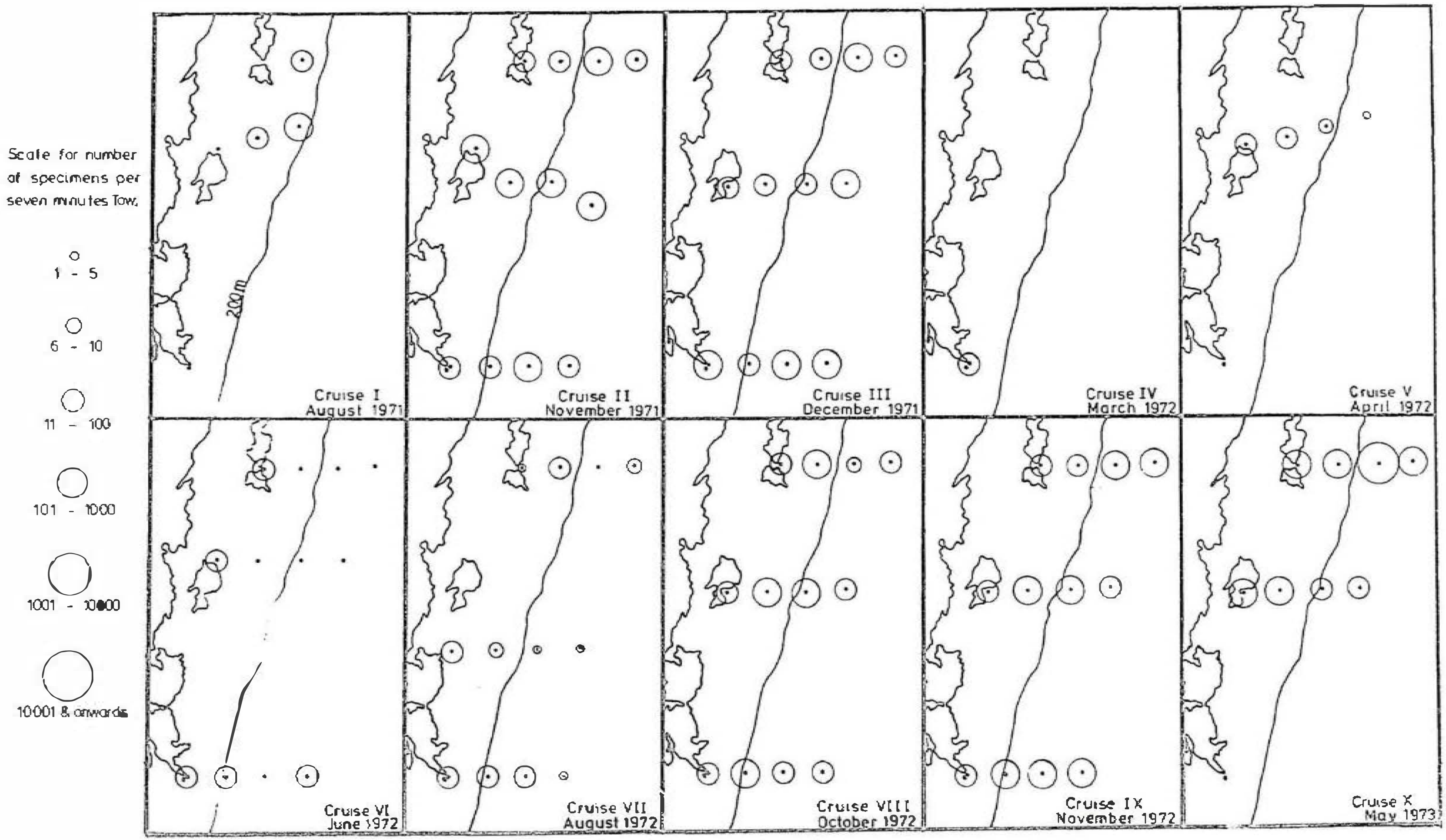

Fig. 18 Distribution of Mecynocera clausi, Cruises I - X.

PARACALANIDAE

Calocalanus contractus

Occurrence................. Fig. 20.

It occurred in Cruise VIII in a number of stations, mainly the southern transect, as a rare to common constituent. It was also taken sporadically in Cruise III and X, all restricted in the coastal shelf waters. It is tolerance to environmental conditions was narrow and was found to prefer cold, low salinity sub-antarctic waters (Fig. 19).

Calocalanus pavo

It was taken at six stations - station 30, 32, 33, 77, 79 and 87 in rare constituent.

Calocalanus styliremis

Occurrence................. Fig. 20

It occurred in most of the stations during Cruise VIII, usually common in number. During late spring and early summer (November and December) cruises, it was rare in oceanic stations, rare to common in coastal waters. It was also captured during Cruise X at two stations - a common constituent at coastal and rare at oceanic stations.

The distribution of this species is uncertain. Farran (1936) recorded it off the Great Barrier Reef. Tanaka (1960) reported it from warm waters of the South China Sea. It was captured in small numbers by Bradford (1972) at the central east coast of New Zealand. Jillett and Michael (1973) found it

PARACALANIDAE

Calocalanus contractus

Occurrence................. Fig. 20.

It occurred in Cruise VIII in a number of stations, mainly the southern transect, as a rare to common constituent. It was also taken sporadically in Cruise III and X, all restricted in the coastal shelf waters. It is tolerance to environmental conditions was narrow and was found to prefer cold, low salinity sub-antarctic waters (Fig. 19).

Calocalanus pavo

It was taken at six stations - station 30, 32, 33, 77, 79 and 87 in rare constituent.

Calocalanus styliremis

Occurrence.................. Fig. 20

It occurred in most of the stations during Cruise VIII, usually common in number. During late spring and early summer (November and December) cruises, it was rare in oceanic stations, rare to common in coastal waters. It was also captured during Cruise X at two stations - a common constituent at coastal and rare at oceanic stations.

The distribution of this species is uncertain. Farran (1936) recorded it off the Great Barrier Reef. Tanaka (1960) reported it from warm waters of the South China Sea. It was captured in small numbers by Bradford (1972) at the central east coast of New Zealand. Jillett and Michael (1973) found it

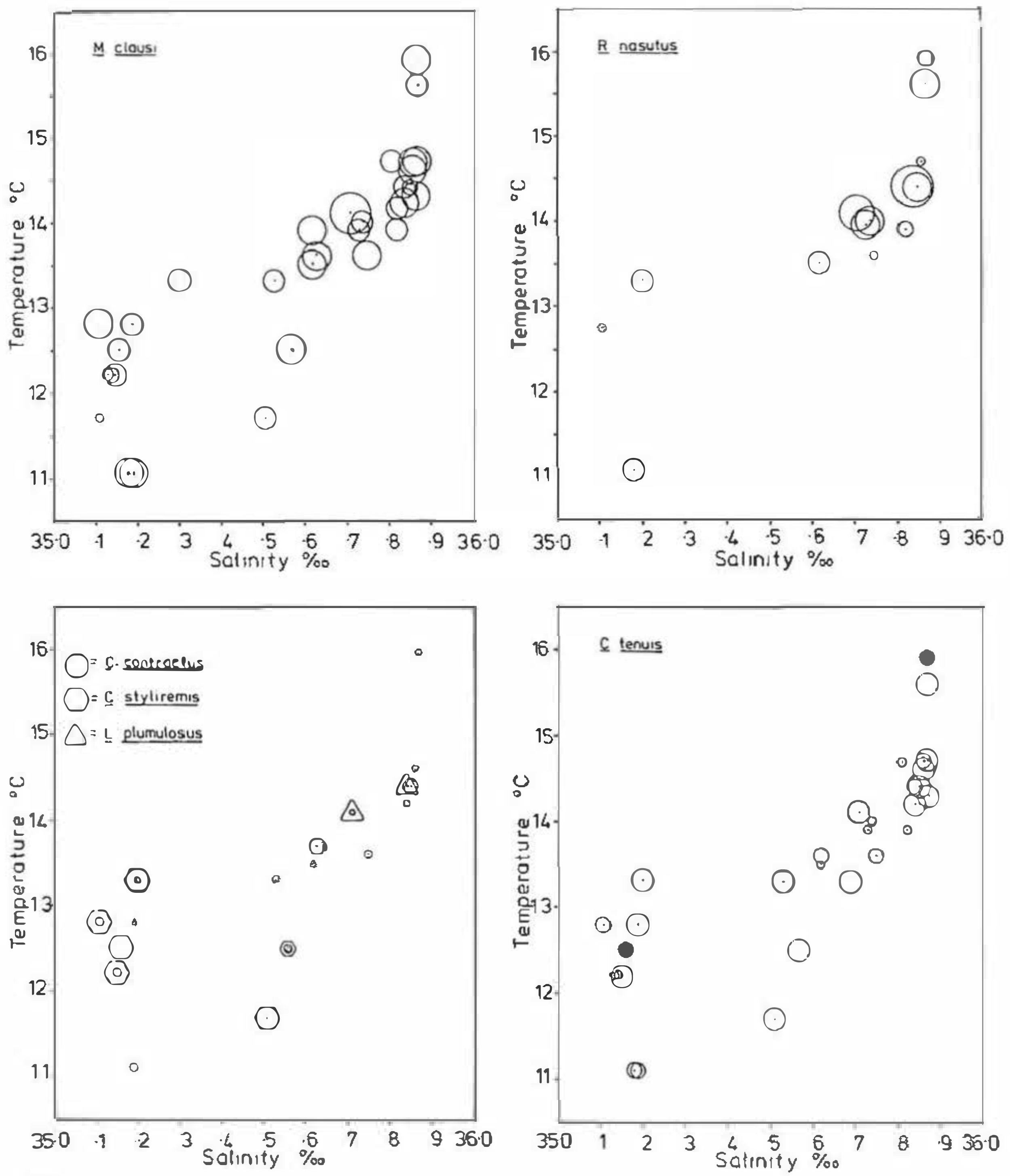

FIG. 19 TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR MECYNOCERA CLAUSI, RHINCALANUS NASUTUS, CALOCALANUS CONTRACTUS, CALOCALANUS STYLIREMIS, LEPTOCALANUS PLUMULOSUS AND CALOCALANUS TENUIS.

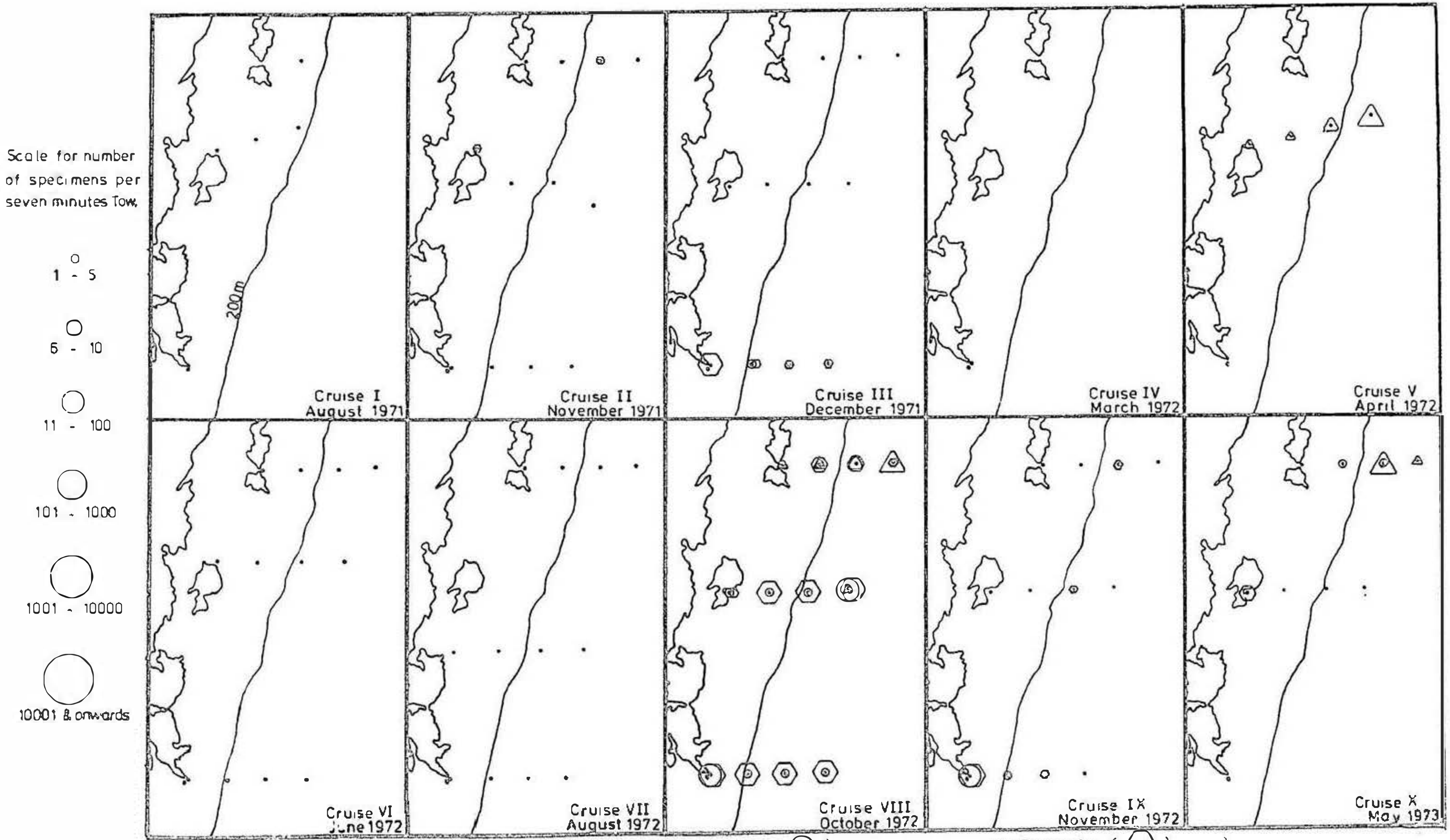

Fig. 20 Distribution of Calocalanus contractus (◯), Calocalanus styliremis (⬡), and Leptocalanus plumulosus (△), Cruises I - X.

at Dusty Sound, southwest New Zealand. To the west of the study area it was encountered by DeDecker and Mombeck (1964) at the surface waters off southeastern Africa.

In the present study, it was found usually with sub-antarctic, cold water species and appeared to prefer such water (Fig. 19).

Calocalanus tenuis

Occurrence................. Fig. 21.

A widespread species occurring usually as a common constituent in almost all the stations throughout the study period. The only cruise which it was not found in oceanic waters, was Cruise II. It had no preference to any particular environment (Fig. 19). As such, its value as an indicator in the oceanic waters is useless, however, since it is a known oceanic species which occurred regularly in the oceanic waters, if found in the inshore coastal water, would indicate the influence of oceanic waters.

Leptocalanus plumulosus

Occurrence.................. Fig. 20.

A common species associated with warm, high salinity sub-tropical waters in the present study. It was encountered during three cruises. In Cruise V, a common species in the oceanic and rare in the coastal waters. During Cruise VII, it was common in oceanic stations at northern transect, rare in a few stations where it was captured. It was taken at two oceanic stations during Cruise X. Its range of tolerance to temperature and salinity was narrow (Fig. 19) and was found to be restricted to warm, high salinity sub-tropical waters.

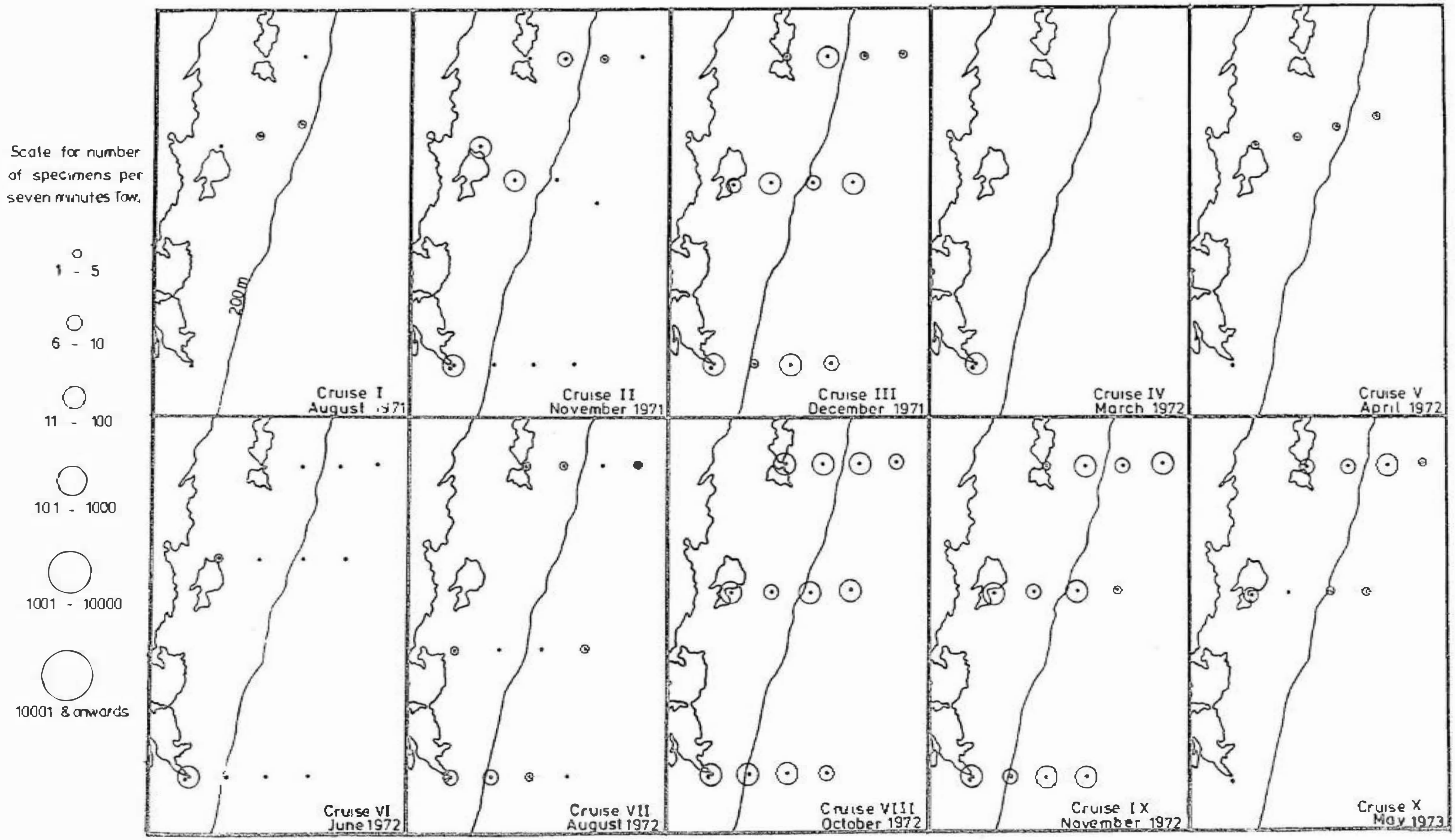

Fig. 21 Distribution of Calocalanus tenuis, Cruises I - X.

Paracalanus parvus

Occurrence............... Fig. 22.

A widespread species occurring in abundant numbers in all coastal stations. It was also taken in a few oceanic stations. Its restricted distribution and abundant number makes it a very useful indicator of such waters. However, one must be very careful in using it as a coastal indicator, due to its abundant numbers. Finding a few specimens of this species in oceanic waters does not suggest the influence of coastal waters. They could be strays from coastal waters, but if found in large numbers, one could be certain of coastal influences.

PSEUDOCALANIDAE

Apart from the three species which were enumerated, the following species could also occur as they were taken in the inshore coastal waters (see Sections I and III). Due to the difficulties involved in identification (they are not readily distinguishable), their occurrence was not studied. The species are: - Clausocalanus mastigophorus, Clausocalanus arcuicornis, Clausocalanus parapergens, Clausocalanus brevipes Clausocalanus jobei.

Clausocalanus ng

Occurrence............... Fig. 23.

It was a widespread species, found in almost all the stations, usually common to abundant in number. The number encountered was mainly higher in oceanic waters than coastal waters. It had no preference to any particular environment

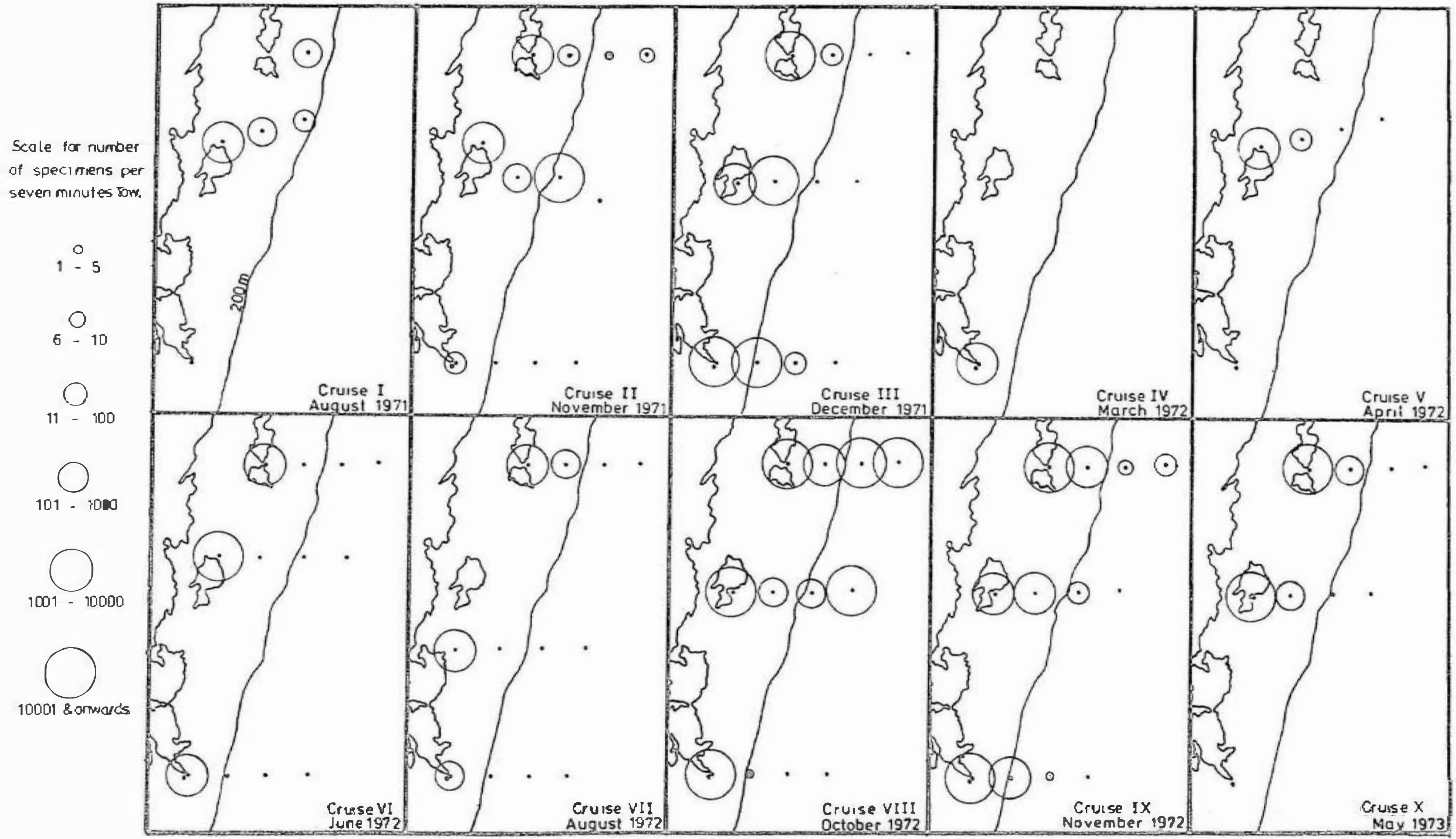

Fig. 22 Distribution of *Paracalanus parvus*, Cruises I - X.

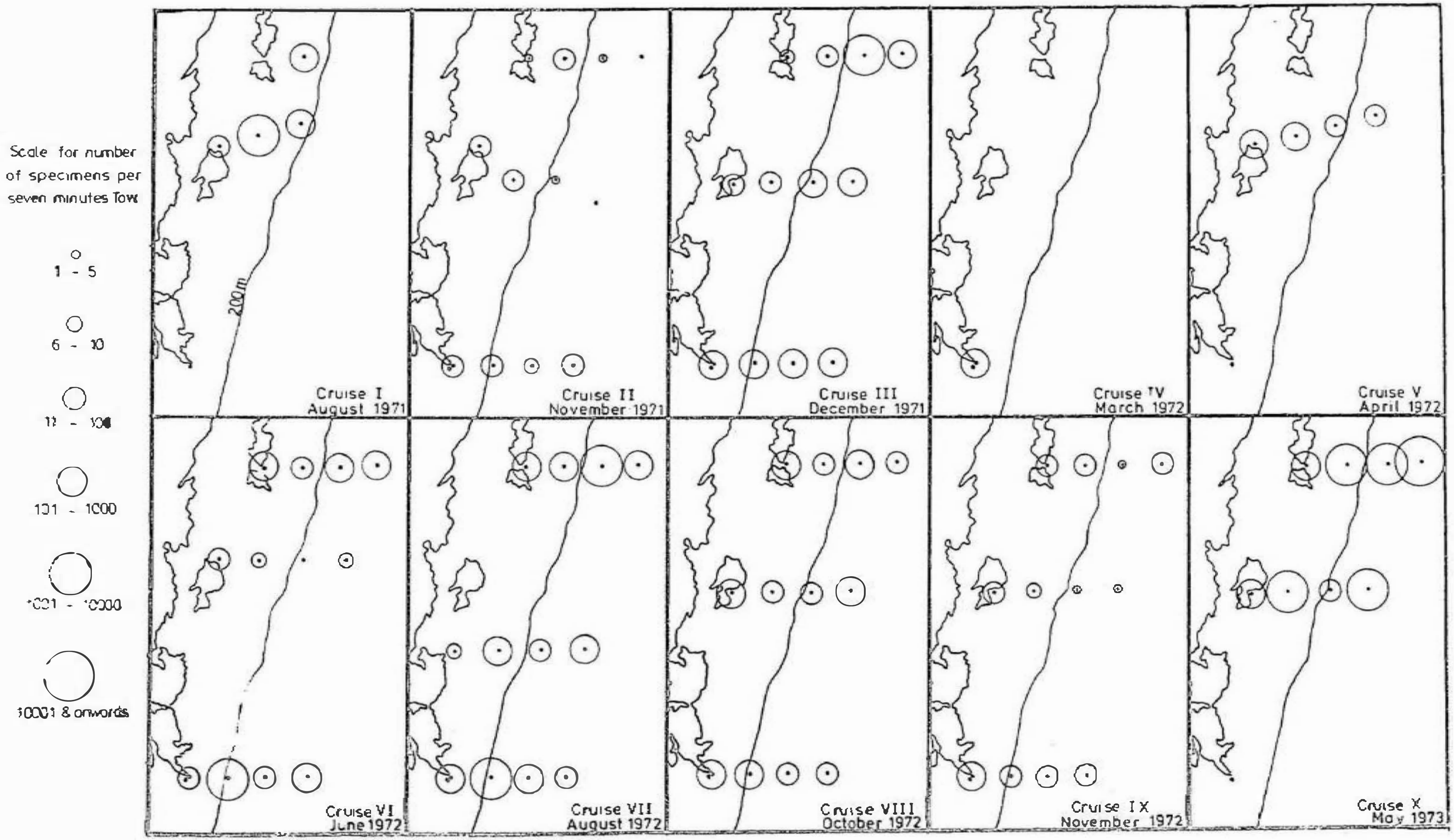

Fig. 23 Distribution of *Clausocalanus ingens*, Cruises I - X.

(Fig. 24). Being found consistantly in the area, it would be a useful indicator of oceanic influences if found in the coastal or inshore coastal waters.

Clausocalanus laticeps

Occurrence.................. Fig. 25.

It was taken at one coastal station during Cruise II. During Cruise VII it occurred in rare constituents in two oceanic stations. It was rare to common in number in several stations (coastal shelf and oceanic) during Cruise VIII. In Cruise IX it was found to be restricted to two southern transect coastal stations.

It was regarded as an Antarctic and sub-Antarctic species by Vervoort (1951, 1957) and Frost and Fleminger (1968). Bary (1959) used it as an "Intolerant Southern sub-Antarctic" indicator. The species was found to be associated with other known sub-Antarctic species and found to prefer such waters (Fig. 24).

Ctenocalanus vanus

Occurrence.................. Fig. 25.

It occurred mainly as a common to very common constituent and usually in the coastal waters. The worldwide distributional records of this species and having been encountered consistantly in inshore coastal waters (Section III), make it appear to be coastal in nature. But since it was not found consistantly in coastal waters, it seems to have been brought into the area by coastal waters from the north, where it was reported to be ubiquitous by Dall (1957a, b; 1958).

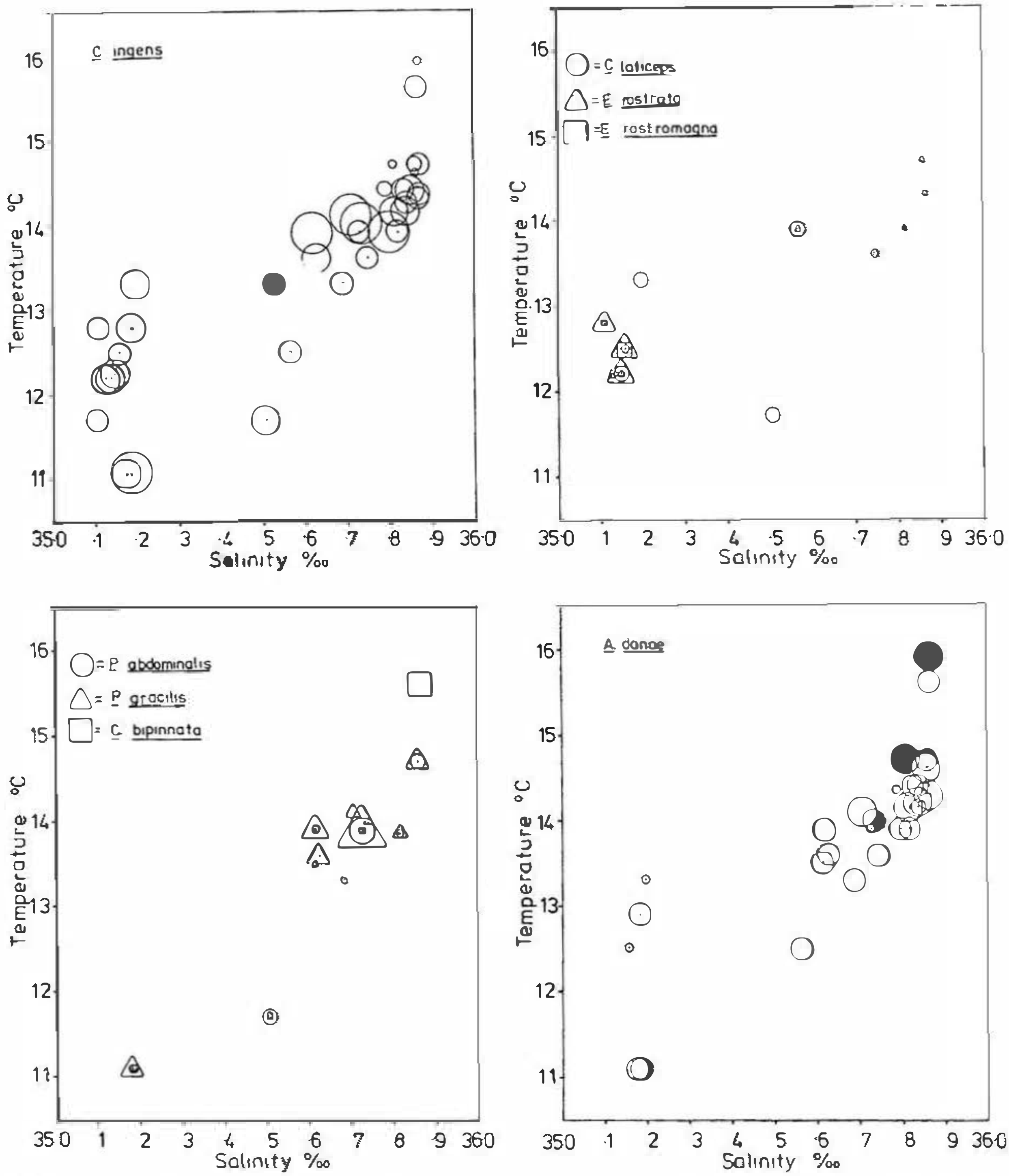

FIG. 24 TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR CLAUSOCALNUS INGENS, CLAUSOCALANUS LATICEPS, EUCHIRELLA ROSTRATA, EUCHIRELLA ROSTROMAGNA PLEUROMAMMA ABDOMINALIS PLEUROMAMMA GRACILIS, CANADACIA BIPINNATA AND ACARTIA DANAE

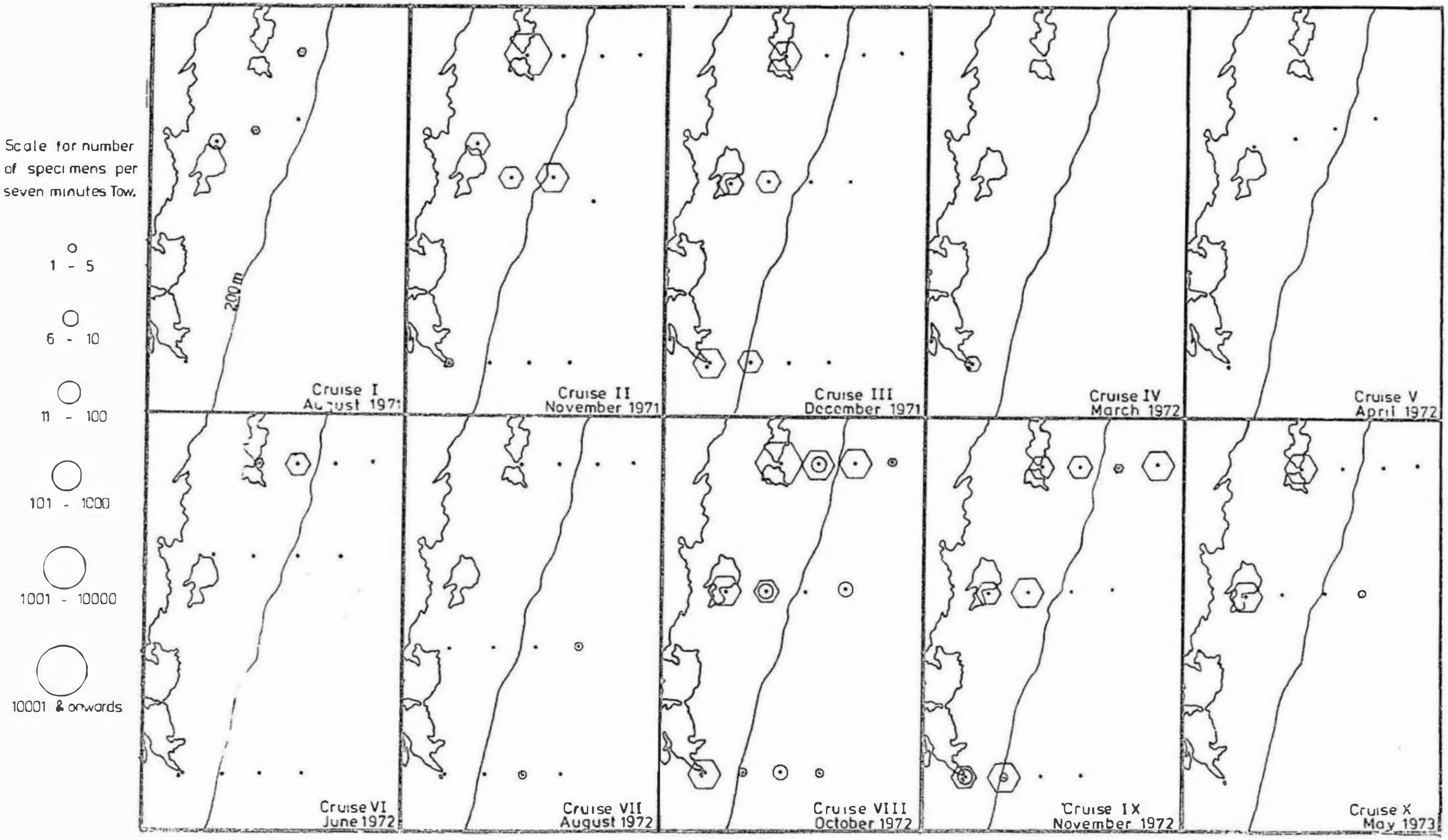

Fig. 25 Distribution of Clausocalanus laticeps (◯) and Ctenocalanus vanus (⬡), Cruises I - X.

AETIDEIDAE

Aetideus pseudarmatus was found once, at Station 78. Six specimens of Chiridius gracilis were taken at Station 70. A specimen each of Euchirella curticauda and Euchirella formosa were captured at Station 83. At Station 44 a single specimen of Euchirella venusta was collected. Undeuchaeta plumosa was found at four stations - Stations 39, 46, 52 and 83.

The stations at which C. gracilis, E. curticauda and U. plumosa were found were either operated during the early hours of the day or during the early hours of the night. It appeared that these are deep water species which migrate to the surface during the night.

Euchirella rostrata

Occurrence............... Fig. 26.

This species was found in a few coastal stations, mainly in rare constituents, during Cruises II and III. During Cruise VIII it was common to very common in number in southern and middle transect oceanic stations, rare in the coastal stations. In Cruise IX it was rare and found only in coastal stations.

Vervoort (1951, 1957) and Bradford (1970, 1972) recorded it in sub-Antarctic waters. It was found to be associated with known sub-Antarctic species of zooplankton and appeared in the present study to prefer such waters (Fig. 24).

Euchirella rostromagna

Occurrence............... Fig. 26.

Occurred in all oceanic stations as rare to common constituents during Cruise II. In Cruise VIII it was found only

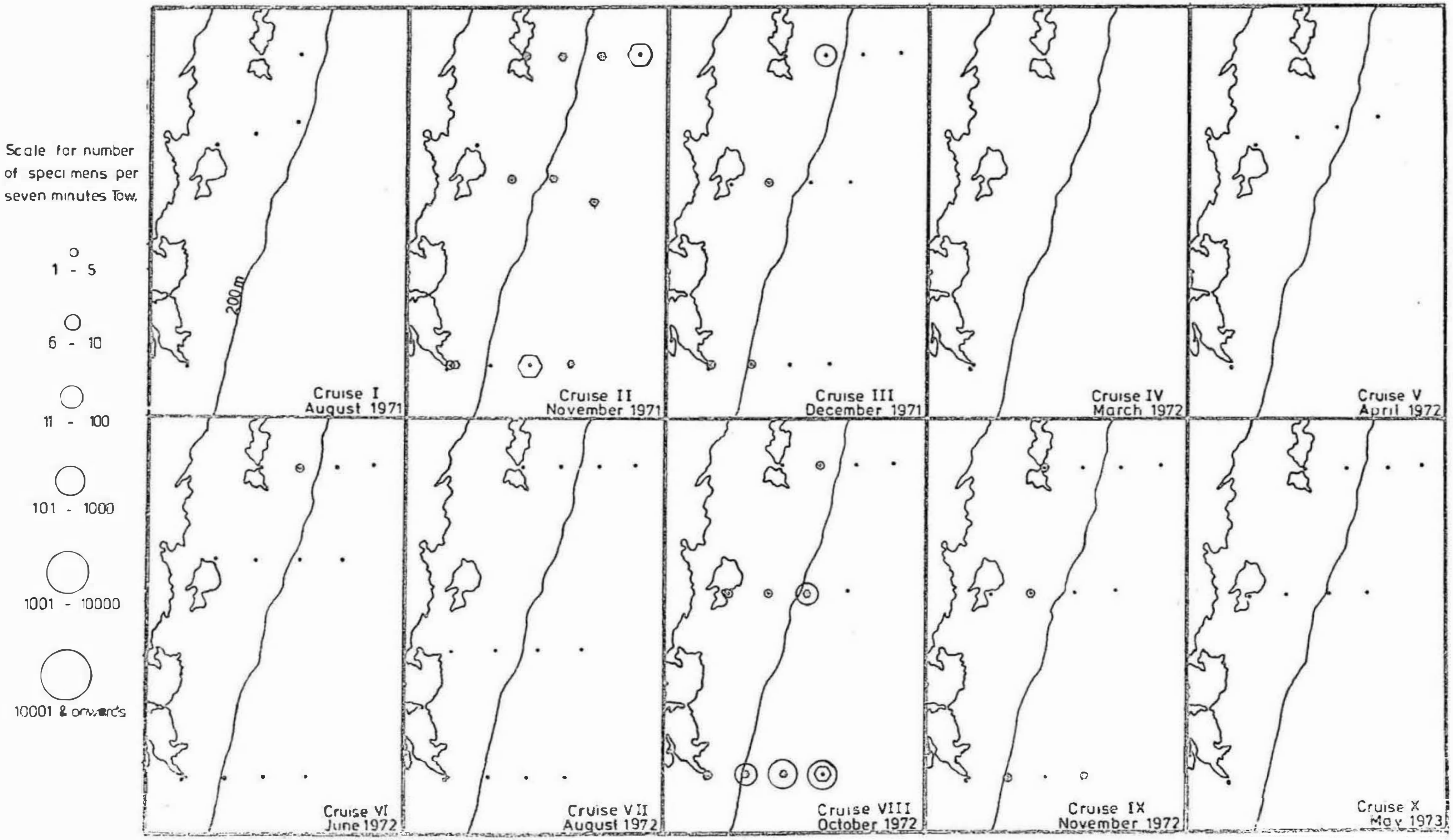

Fig. 26 Distribution of Euchirella rostrata (◯) and Euchirella rostromagna (⬡), Cruises I - X.

in the middle and southern transect stations in oceanic waters in rare to common numbers. A single specimen was also captured in Cruise IX at one station - Station 73.

Vervoort (1951) regarded this species as an inhabitant of moderately deep waters of the Antarctic. Vervoort (1957, 1965) considered it to be the characteristic species of Antarctic waters. This species had not been reported outside the Antarctic region. Its presence in the present study area strongly suggests the presence of sub-Antarctic waters. The presence of it in the area could possibly indicate upwelling, however, other findings (finding only immature specimens of Sagitta gazellae - adults are known to inhabit moderately deep water - with E. rostromagna) suggests that upwelling is not possible. Its preference to cold, low salinity sub-Antarctic water was strong (Fig. 24).

EUCHAETIDAE

Euchaeta acuta was taken at four stations - Stations 16, 27, 82 and 83.

PHAENNIDAE

One female specimen, Phaenna spinifera, was captured at Station 82.

SCOLECITHRICIDAE

Two species of Scolecithrix occurred in the area. S. bradyi was found at three stations - Station 11, 16 and 71. Specimens of S. danae were captured at Station 66.

CENTROPAGIDAE

Centropages australiensis

Occurrence.................... Fig. 27.

Occurred in common to abundant numbers mainly in coastal waters during all cruises. Its restricted distribution in coastal waters makes it very useful as an indicator of such waters.

Centropages bradyi

Occurrence......................Fig. 28.

A widespread species found in almost all the samples collected, usually as a common constituent.

Dall (1957a, b) reported it from southeastern Australian coastal and Bass Strait waters. Kott (1957) considered it as an indicator of southern coastal waters of Australia.

METRIDIIDAE

Pleuromamma abdominalis

Occurrence.................... Fig. 29.

Occurred sporadically in all cruises except Cruise I, IV and VIII. A common constituent in the oceanic stations encountered and rare to common in the coastal waters. It was taken in usually either early hours of the day or in the early hours of the night. This showed that it migrated to deep water during mid-day hours. However, since it was found in a number of coastal stations where the depth was between 50 and 100m it could not have migrated from offshore deep water. From the available temperature and salinity, it was found to prefer warm,

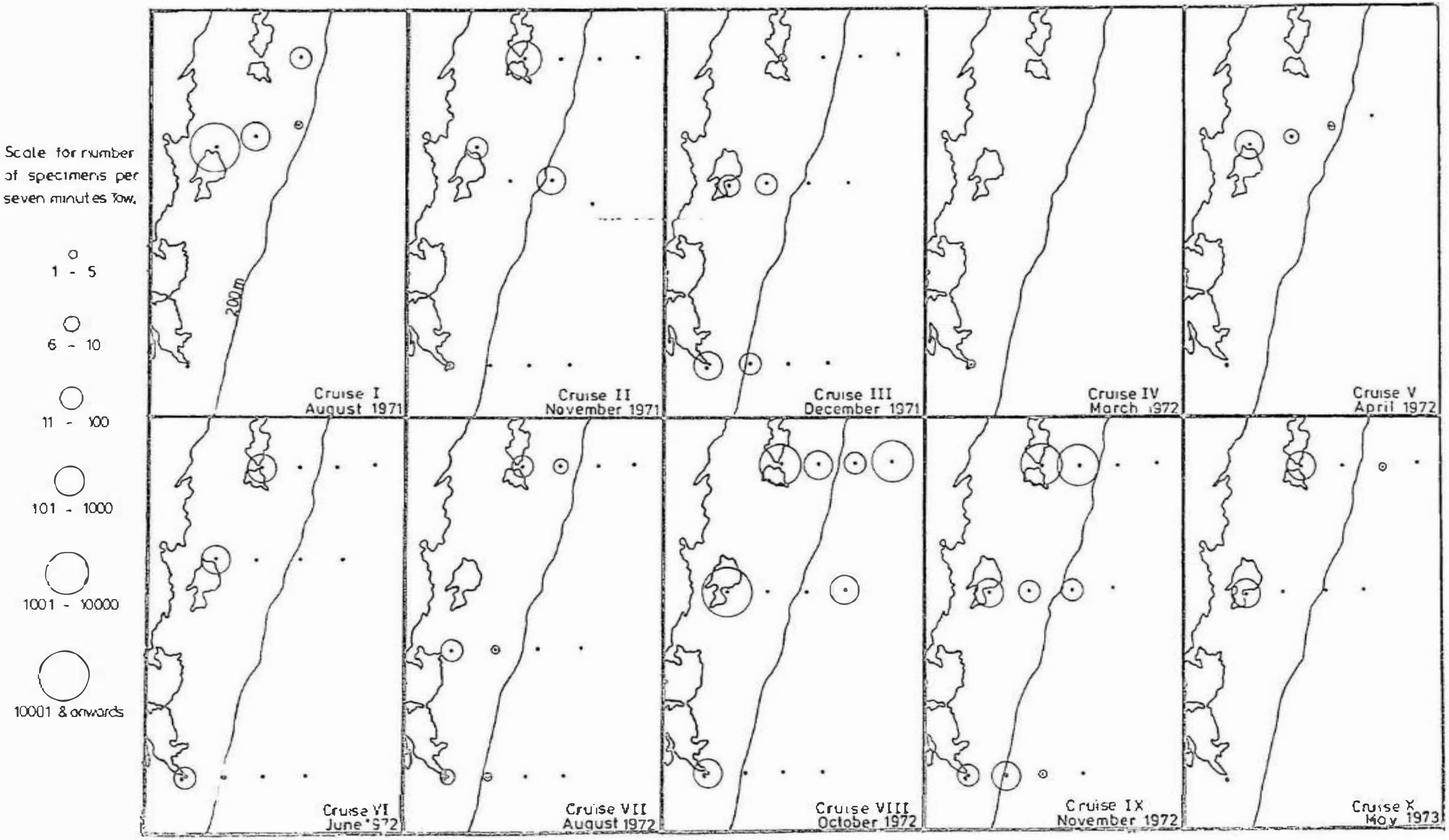

Fig. 27 Distribution of <u>Centropages</u> <u>australiensis</u>, Cruises I - X.

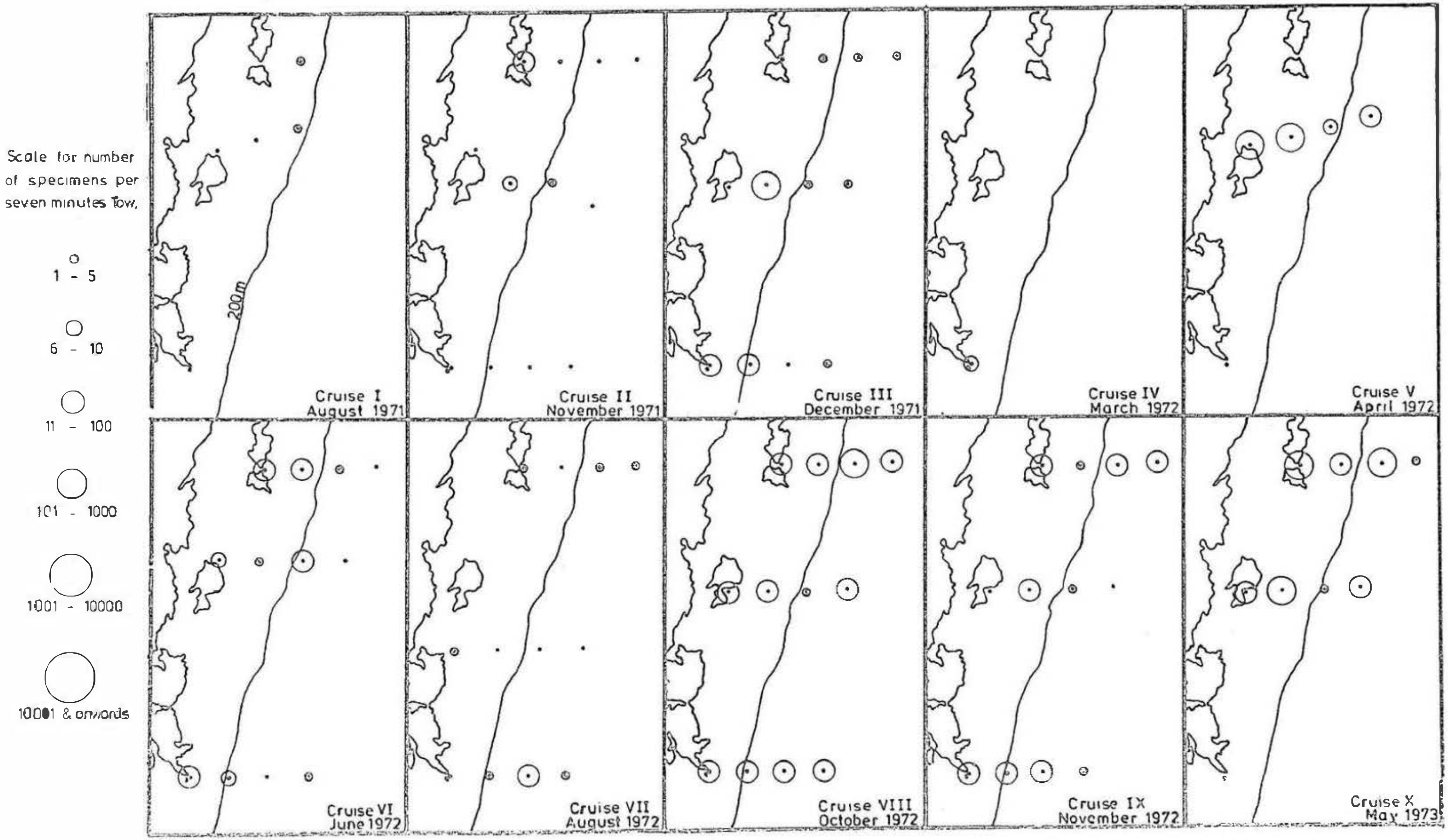

Fig. 28 Distribution of Centropages bradyi, Cruises I - X.

high salinity sub-tropical water (Fig. 24).

Pleuromamma gracilis

Occurrence............... Fig. 29.

The occurrence of P. gracilis and P. abdominalis appeared to be very similar, although the number taken was greater in P. gracilis. Both species were considered as indicators of surface offshore Tasmanian waters by Kott (1957). Like P. abdominalis, it prefered warm, high salinity water (Fig. 24).

Pleuromamma xiphias

A few specimens were taken once at Station 83.

TEMORIDAE

Temora turbinata

Taken at two stations - Stations 66 and 67 - during Cruise VIII. Dakin and Colefax (1940) and Kott (1957) found it to be the most common species in the coastal waters of New South Wales. Kott (1957) regarded it as an indicator of Northern Coastal waters of New South Wales. The presence of this species in the area suggests the influence of such waters.

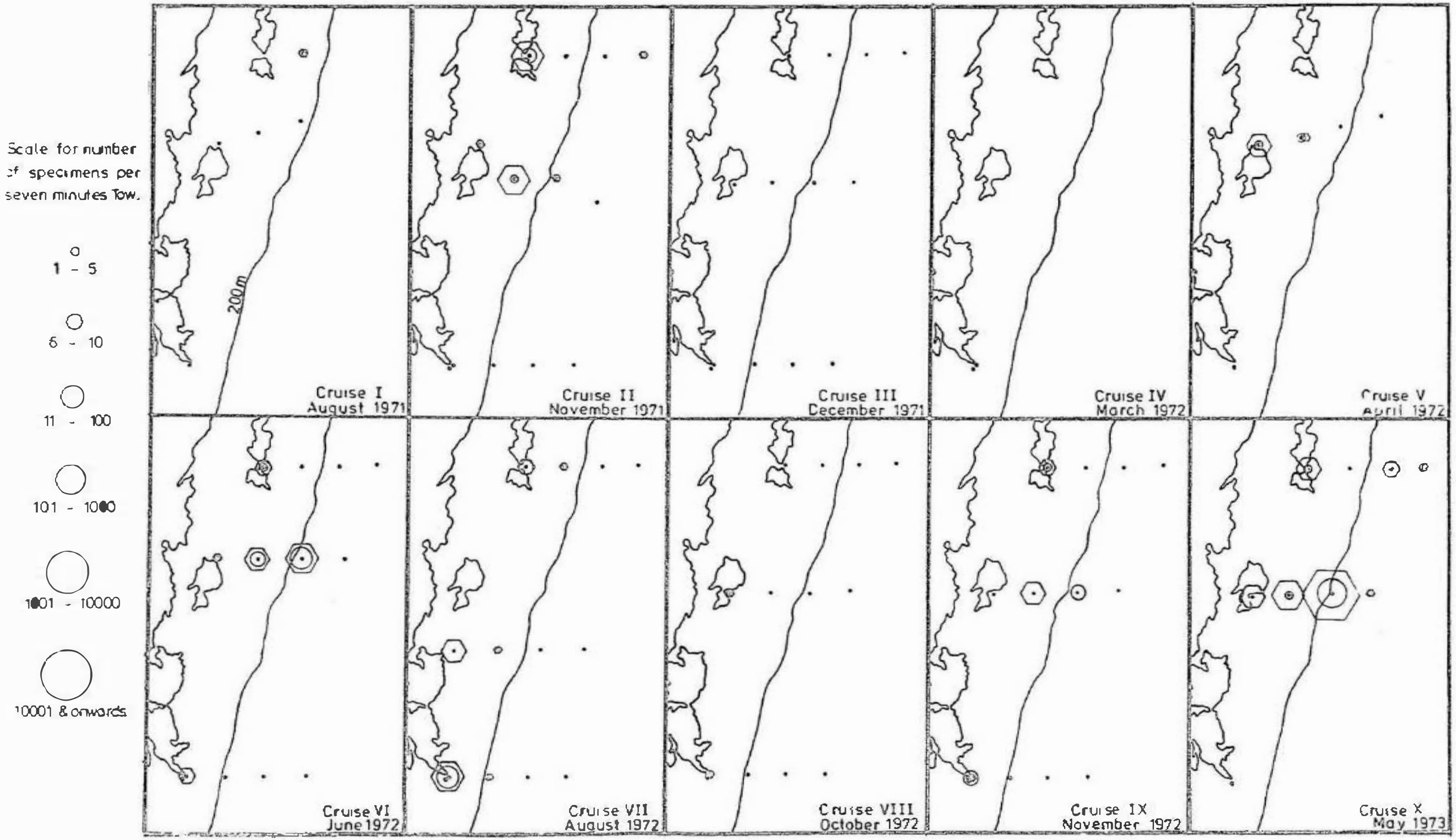

Fig. 29 Distribution of Pleuromamma abdominalis (◯) and Pleuromamma gracilis (⬡), Cruise I - X.

LUCICUTIIDAE

Lucicutia flavicornis

Occurrence................. Fig. 30.

Occurred in a few coastal stations as rare to common constituents during Cruises VII and IX. It was also taken at two stations in Cruise X - a very common constituent in the oceanic and rare in the coastal stations.

HETERORHABDIDAE

Heterorhabdus papilliger

Occurrence................. Fig. 30.

Found sporadically in a number of stations, both in coastal and oceanic waters, in rare to common constituents.

CANDACIIDAE

One specimen of Candacia armata was found at Station 80. Candacia tenuimana occurred at Station 70 and a single specimen of Paracandacia simplex was captured at Station 58.

Candacia bipinnata

Occurrence................. Fig. 30.

Occurred sporadically in all cruises except Cruise II. During Cruises II, VII and VIII it was rare and found only in the coastal waters. In the remaining months, where it occurred, it was rare to common and found both in coastal and oceanic waters.

Dakin and Colefax (1940) found it to be the most common species off the New South Wales coast. In the present study

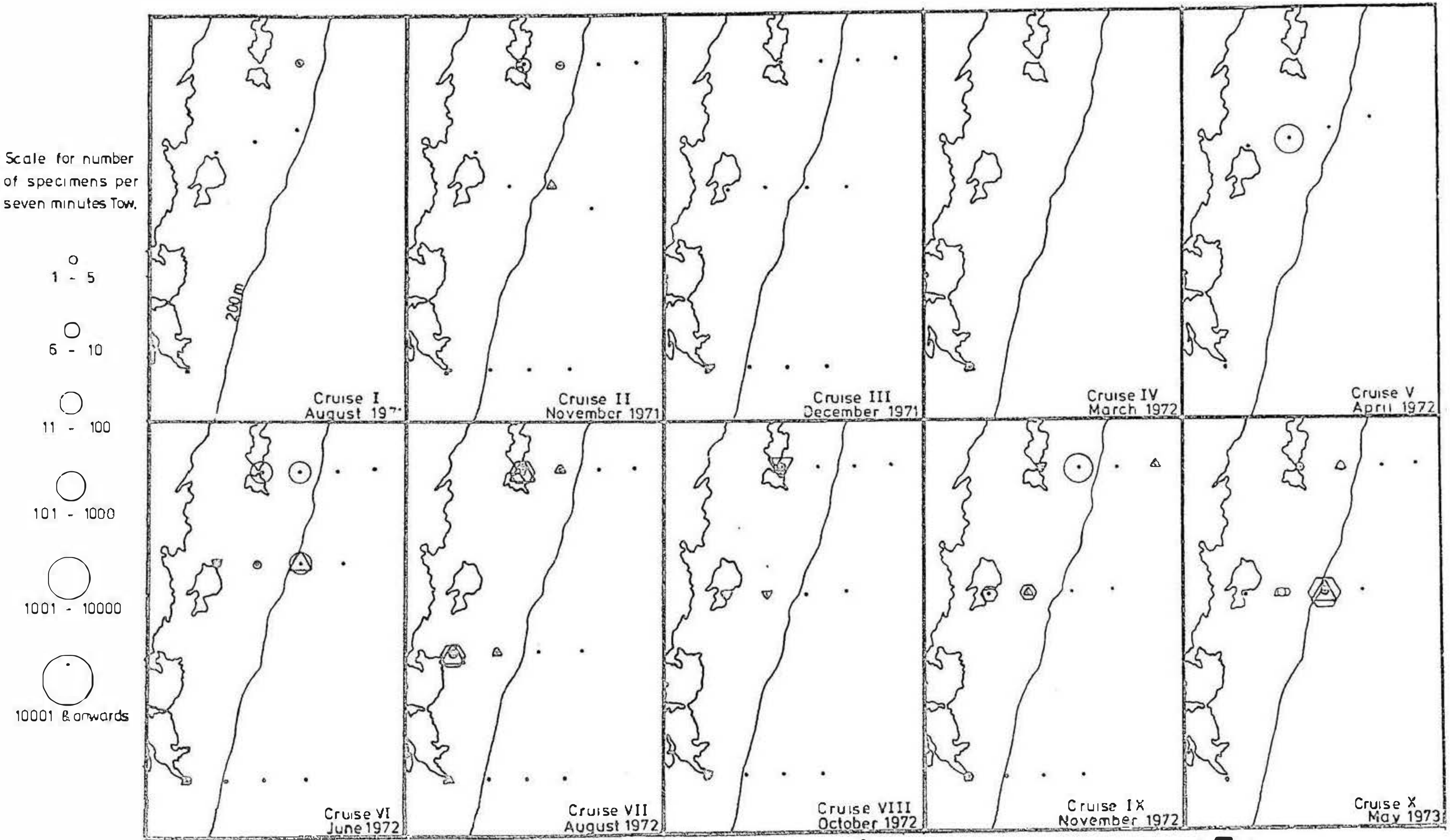

Fig. 30 Distribution of Lucicutia flavicornis (△), Heterorhabdus papilliger (●), Candacia bipinnata (○) and Labidocera tasmanica (▽), Cruises I - X.

it was found to prefer warm, high salinity waters (Fig. 24). The presence of it suggests the influence of warm water from the north.

PONTELLIDAE

Labidocera tasmanica

Occurrence............... Fig. 30.

Usually a rare species, occurring sporadically in the coastal waters.

ACARTIIDAE

Acartia clausi

Occurrence............... Fig. 31.

Occurred usually in very common to abundant numbers in coastal waters. It was also found in a few oceanic stations, but the number encountered was mainly rare. The presence of this species in oceanic waters would clearly indicate the influence of coastal waters.

Acartia danae

Occurrence............... Fig. 32.

Widespread, usually common to very common species in the oceanic as well as in coastal waters. The number taken was higher in the warm, high salinity sub-tropical oceanic waters.

Dall (1957a, 1958) found it to be abundant off the southeastern coastal waters of Australia. A warm water species by its previous distributional records. Although a small number of this species was found in cold, low salinity waters,

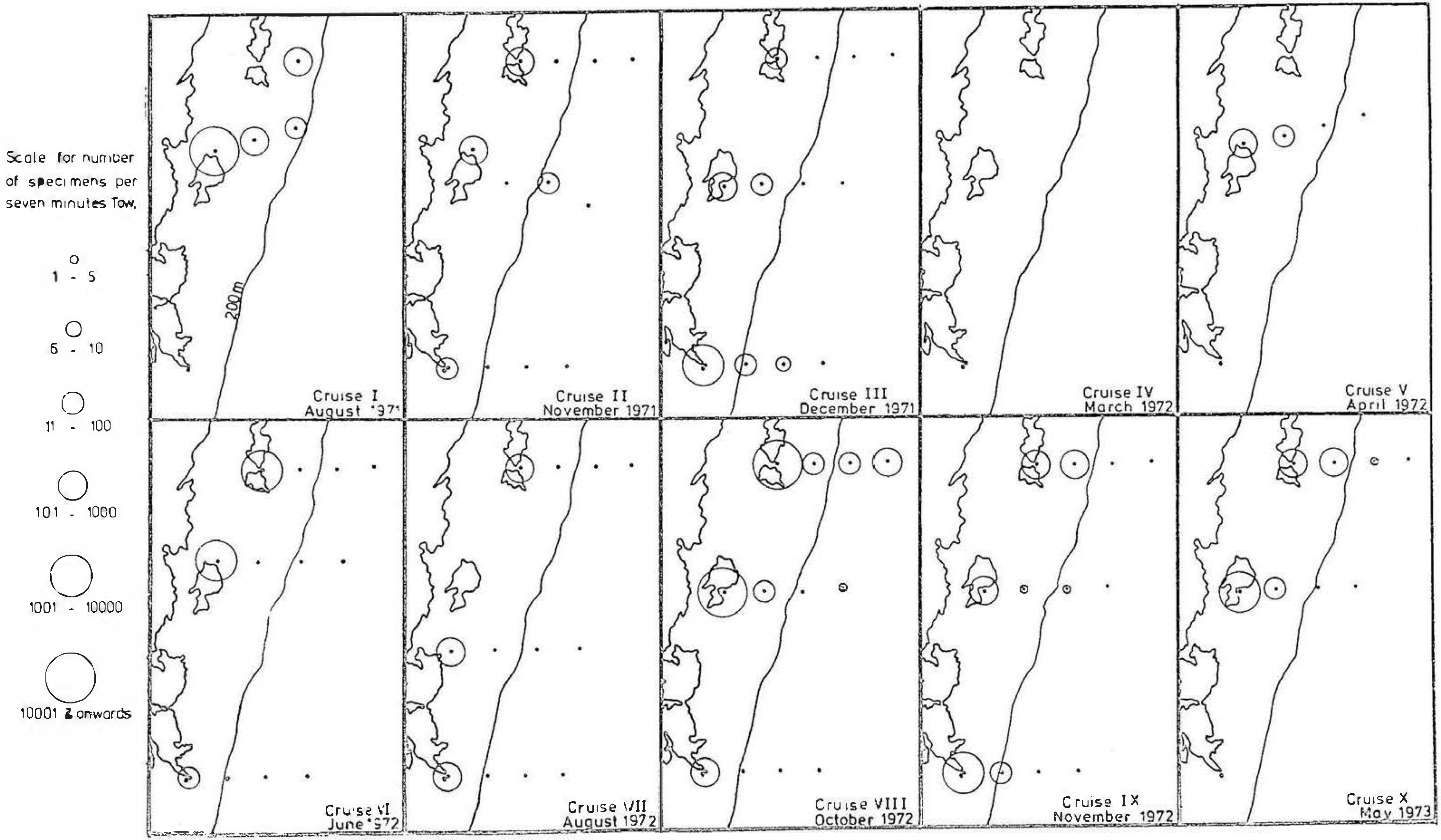

Fig. 31 Distribution of *Acartia clausi*, Cruises I - X.

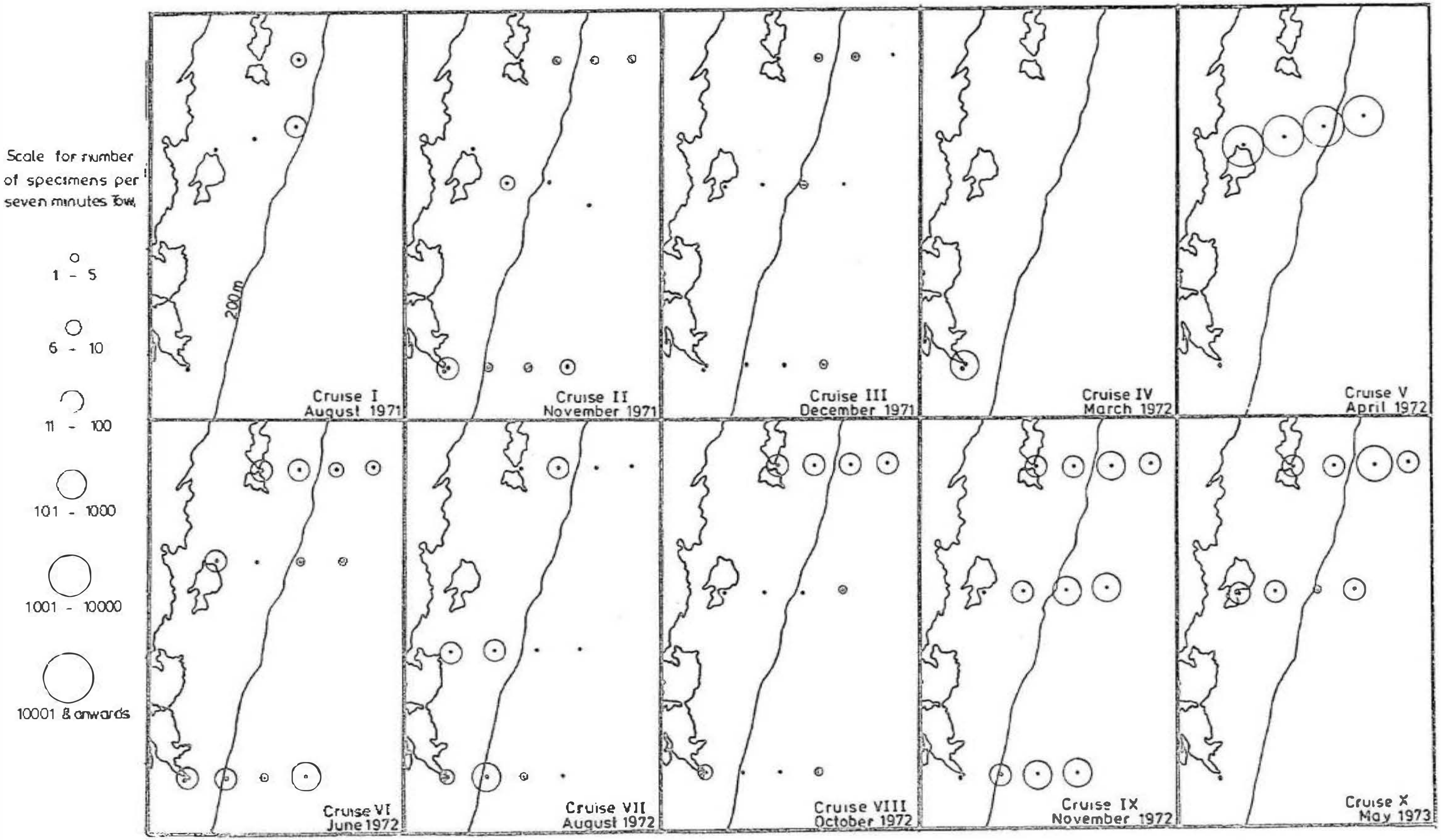

Fig. 32 Distribution of *Acartia danae*, Cruises I - X.

the preference to warm, high salinity sub-tropical water was marked (Fig. 24).

ONCAEIDAE

Oncaea conifera occurred sporadically at a few coastal and oceanic stations (Fig. 33). A few specimens of Oncaea /e ~~meditarranea~~ were identified from Stations 66 and 67, during Cruise VIII.

Oncaea media

Occurrence............. Fig. 33.

Found in a number of oceanic stations during Cruises VIII and X as a rare to common constituent. During the remaining cruises it usually occurred in coastal waters.

Dall (1957a, b; 1958) reported it as an abundant species in the southeastern coastal waters of Australia and the central Tasman Sea. It was found to prefer warm, high salinity sub-tropical waters (Fig. 34).

Oncaea venusta

Occurrence................ Fig. 35.

Occurred in all cruises. The number encountered was mainly common to very common in oceanic waters during Cruises VIII, IX and X. During the remaining cruises it was rare and found in both coastal and oceanic waters.

Dakin and Colefax (1940) found it to be one of the commonest species off the eastern coast of New South Wales. Dall (1957a, b; 1958) reported it to be abundant in the southeastern coastal waters of Australia and the central Tasman

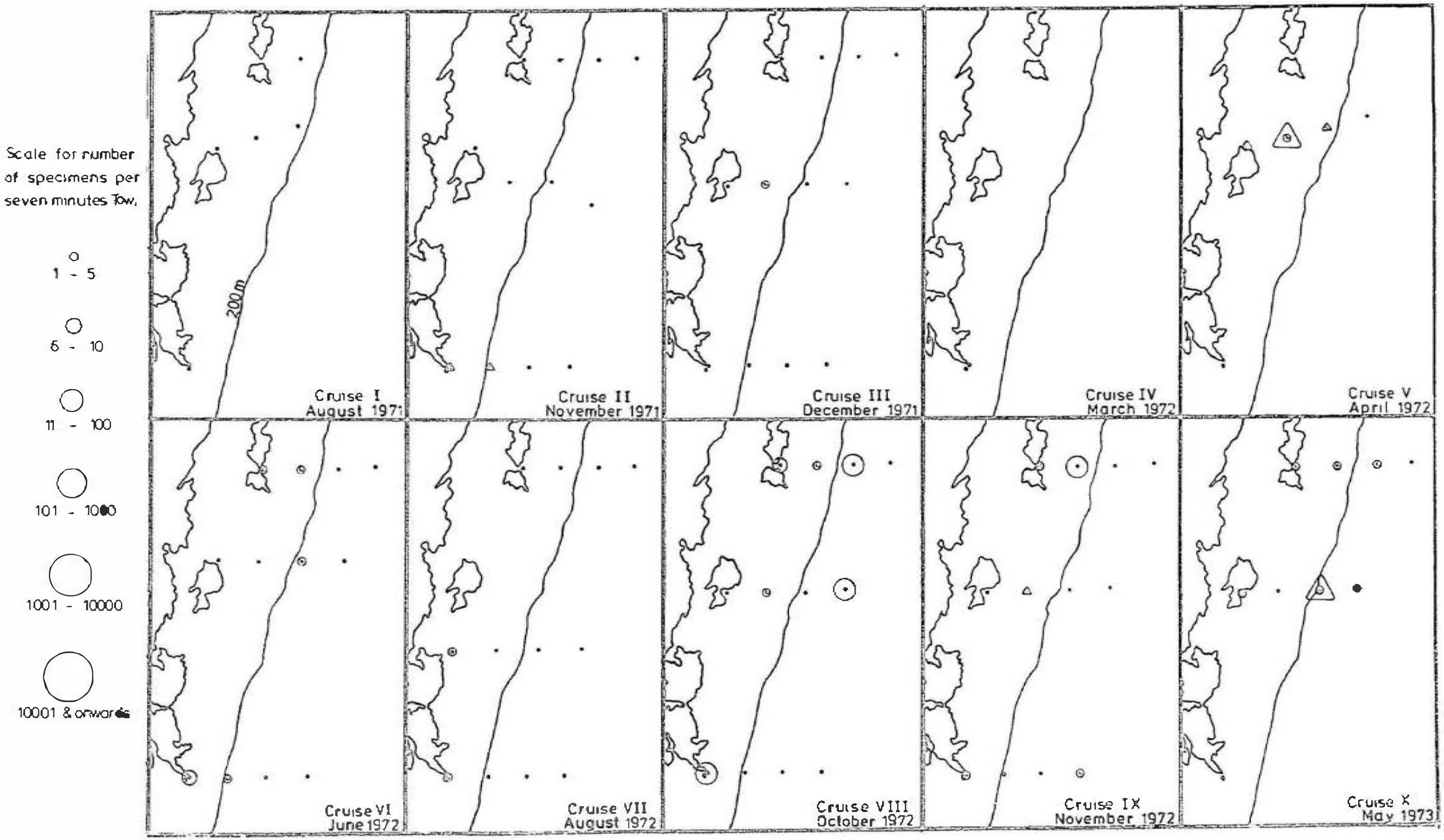

Fig. 33 Distribution of Oncaea conifera (△) and Oncaea media (○), Cruises I - X.

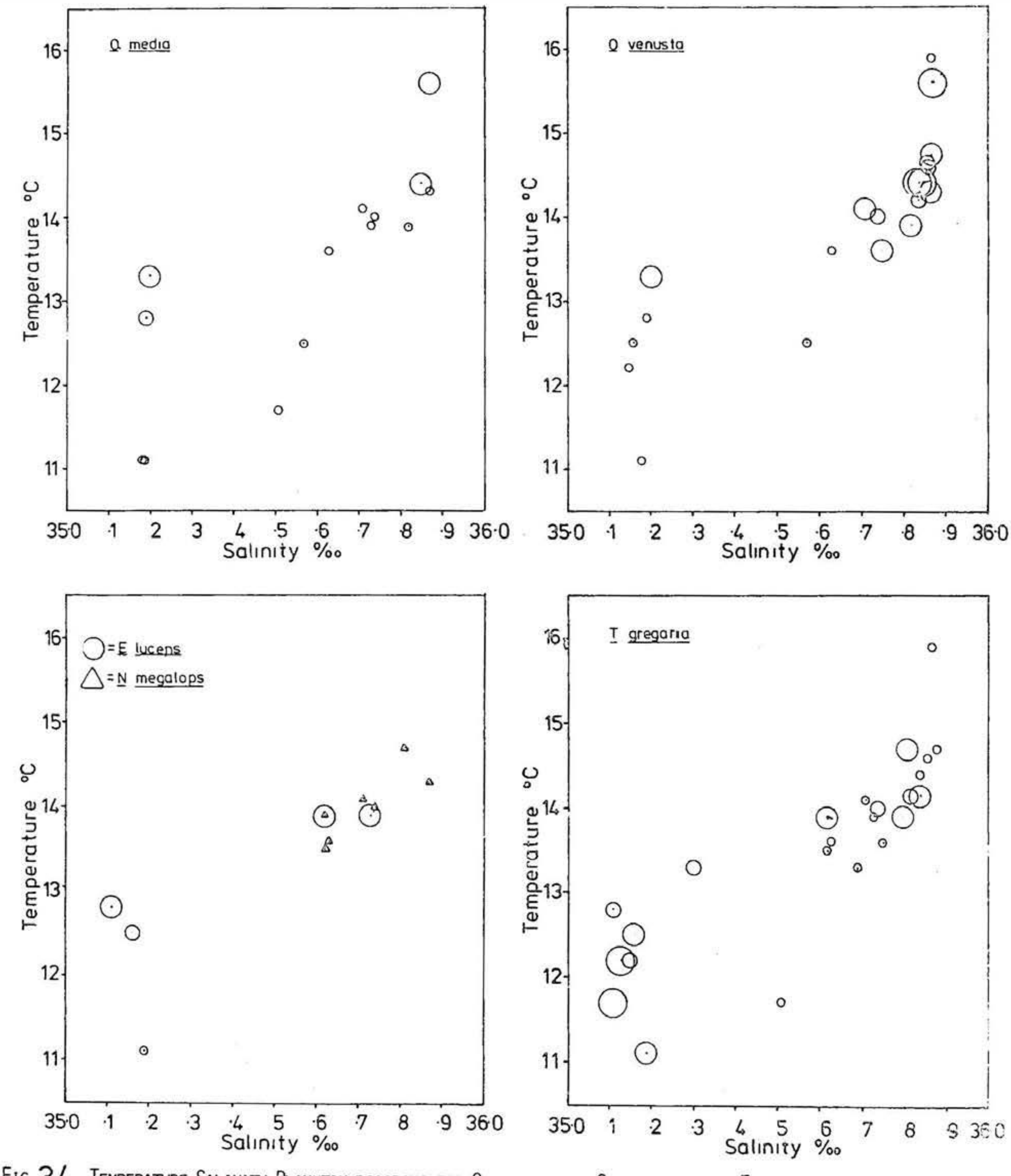

FIG. 34 TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR ONCAEA MEDIA, ONCAEA VENUSTA, EUPHAUSIA LUCENS, NEMATOSCELIS MEGALOPS AND THYSANOESSA GREGARIA.

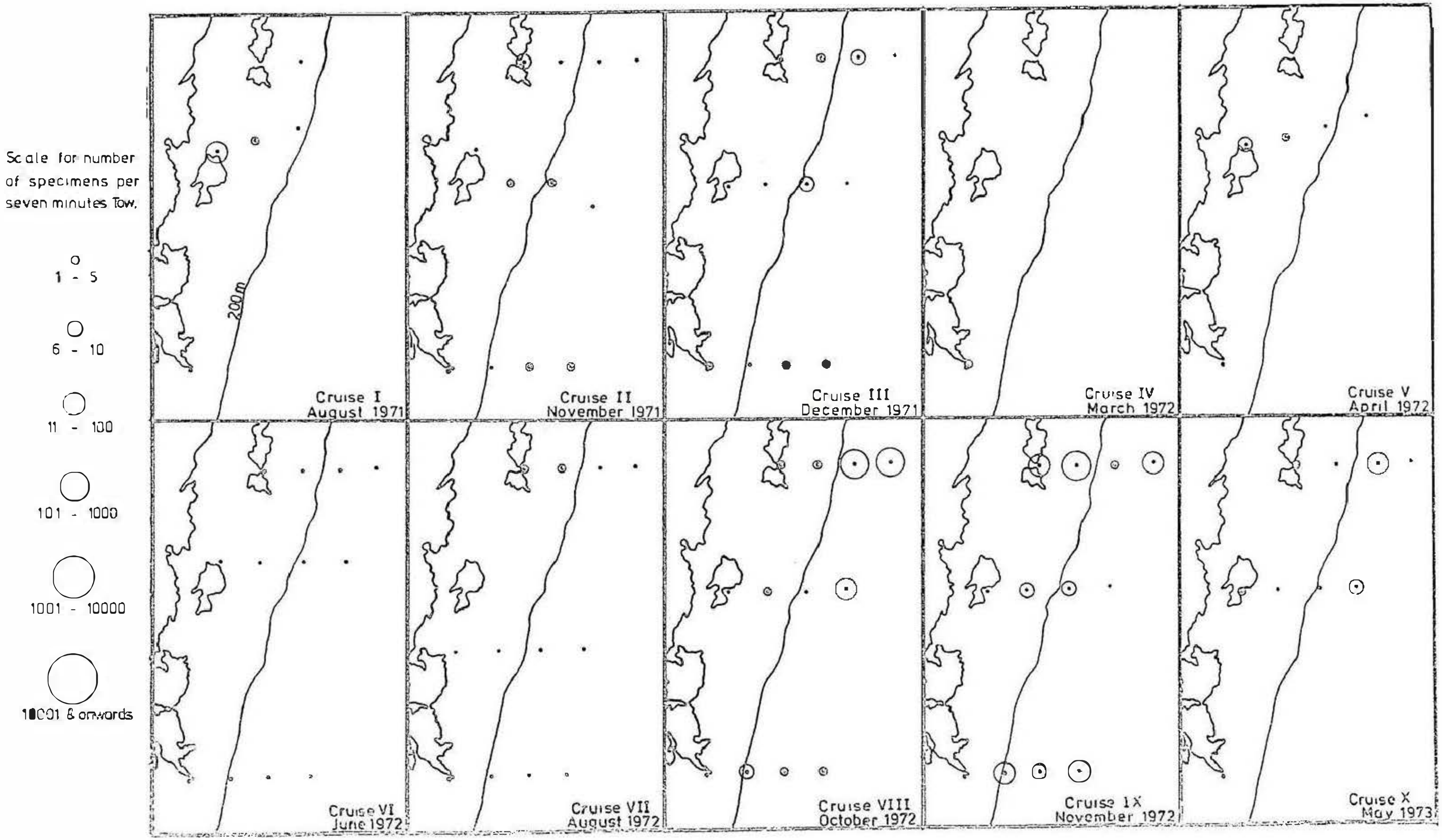

Fig. 35 Distribution of Oncaea venusta, Cruises I - X.

Sea. In the present study the greatest concentration was with warm, high salinity sub-tropical waters (Fig. 34).

EUPHAUSIACEA

Euphausia lucens

Occurrence................ Fig. 36.

Occurred at a few stations during late winter to early summer cruises (August to December) as a rare to common constituent. A few specimens were also taken at three stations in Cruise X.

John (1936) found its distribution to be between Antarctic Convergence to the south and sub-tropical zone, just north of sub-tropical convergence to the north. Bary (1956) and Bradford (1972) found it occasionally off the east coast of the South Island of New Zealand. According to Bradbury (1972) it has no tendency to favour any particular region within the region (Southern Ocean, south of Australia) in regard to either latitude or distance from the Antarctic Convergence.

However, Bary (1959) used it as an indicator of northern sub-Antarctic waters in the southern New Zealand waters.

In the present study it was usually found with sub-Antarctic zooplankton species. However, during Cruise X it was found with warm, sub-tropical species, where the temperature and salinity were high. From the available temperature and salinity values, it seemed that it had no preference to any particular water mass (Fig. 34), in the area. This suppliments the findings of John (1936) and Bradbury (1972).

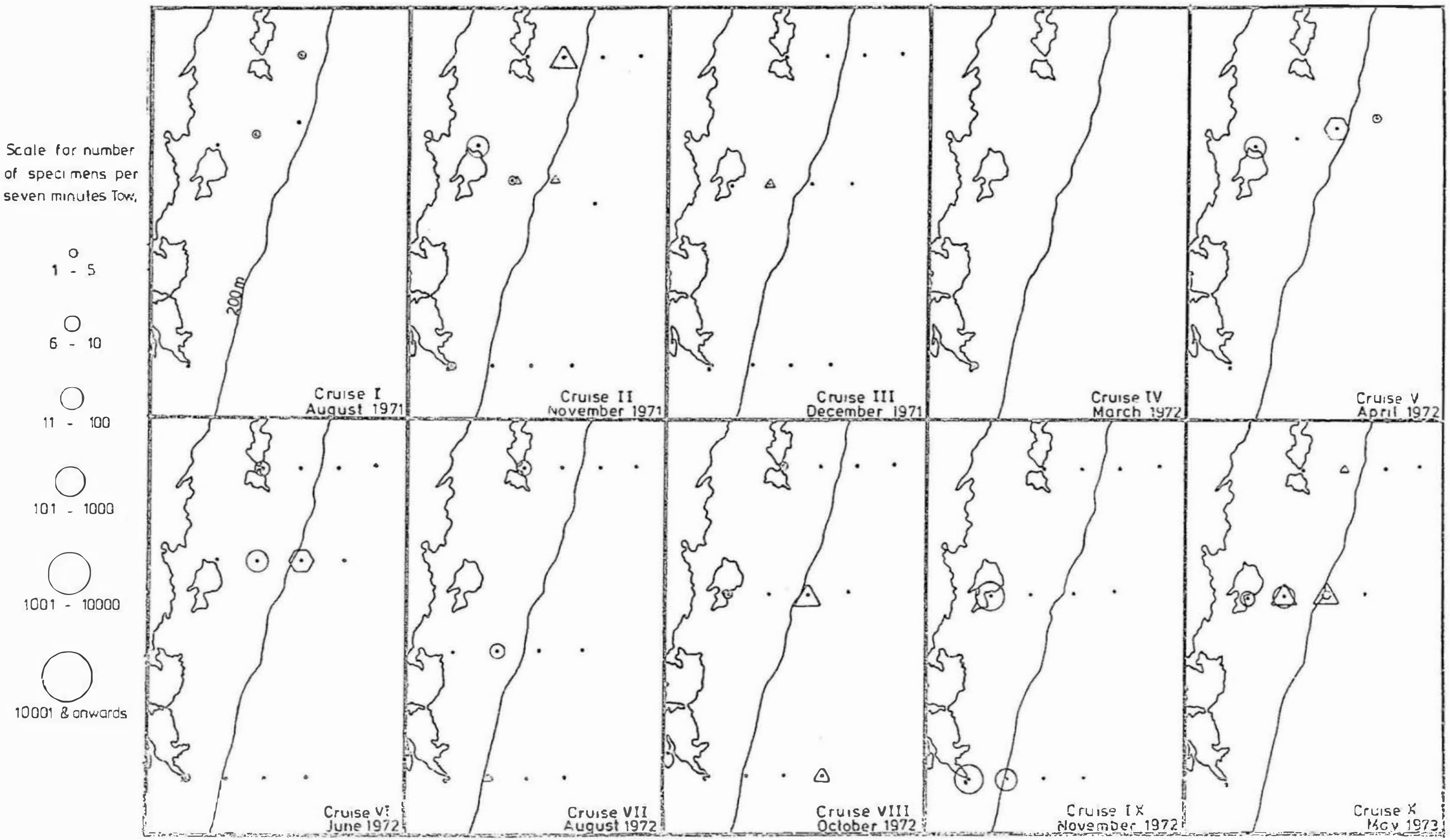

Fig. 38 Distribution of *Euphausia lucens* (△), *Euphausia recurva* (⬡) and *Nyctiphanes australis* (○), Cruises I - X.

Euphausia recurva

Occurrence.............. Fig. 36.

Occurred at four oceanic stations during Autumn and early Winter cruises, rare to common in number.

It is a known tropical, sub-tropical warm water species (Lomakina, 1964; Mauchline and Fisher, 1969). Sheard (1965) found it to have affinity to Central Tasman and southwest Tasman water masses. In the present study it was found to be restricted to warm months and occurred only in oceanic waters.

Euphausia similis

A few specimens were found at Station 83 during Cruise X.

Euphausia similis var *armata*

Taken at two stations - a few specimens at Station 10 and Station 83.

Euphausia longirostris

A single specimen was captured at Station 83 during Cruise X.

Nyctiphanes australis

Occurrence.............. Fig. 36.

Found in coastal waters, usually common, in all cruises except during Cruise III.

It is a coastal inhabitant of New Zealand and southeastern coastal waters of Australia (Mauchline and Fisher, 1969).

Bary (1959) used it as an indicator of coastal waters in the southern New Zealand waters. Its restriction to coastal waters can be readily seen in the present study.

Nematoscelis megalops

Occurrence................ Fig. 37.

Occurred in a number of stations, mainly in the oceanic waters as rare to common constituents during Cruise II and Cruise III. A few specimens were taken at two stations in Cruise V. It occurred at only one station during Cruise VI. It again appeared at a few stations during Cruises IX and X in rare numbers.

This species was recorded by Bary (1956) and Bradford (1972) in the southern New Zealand waters. Shead (1965) described it (as N. difficilis - see Section I) as having affinity to Central Tasman and southwest Tasman water masses. In the present study it seemed to prefer warm, high salinity sub-tropical water (Fig. 34).

Thysanoessa gregaria

Occurrence

A widespread oceanic species taken in all cruises, rare to very common constituents.

In the South Pacific Ocean it was recorded as far north as the New South Wales coast (Dakin and Colefax, 1940) and as far south as Macquarie Island (Tattersall, 1918), Bary (1956) and Bradford (1972) found it in the southern New Zealand waters. Bary (1959) used it as an indicator of "Tolerant" southern sub-antarctic waters. Shead (1965) considered it to have an

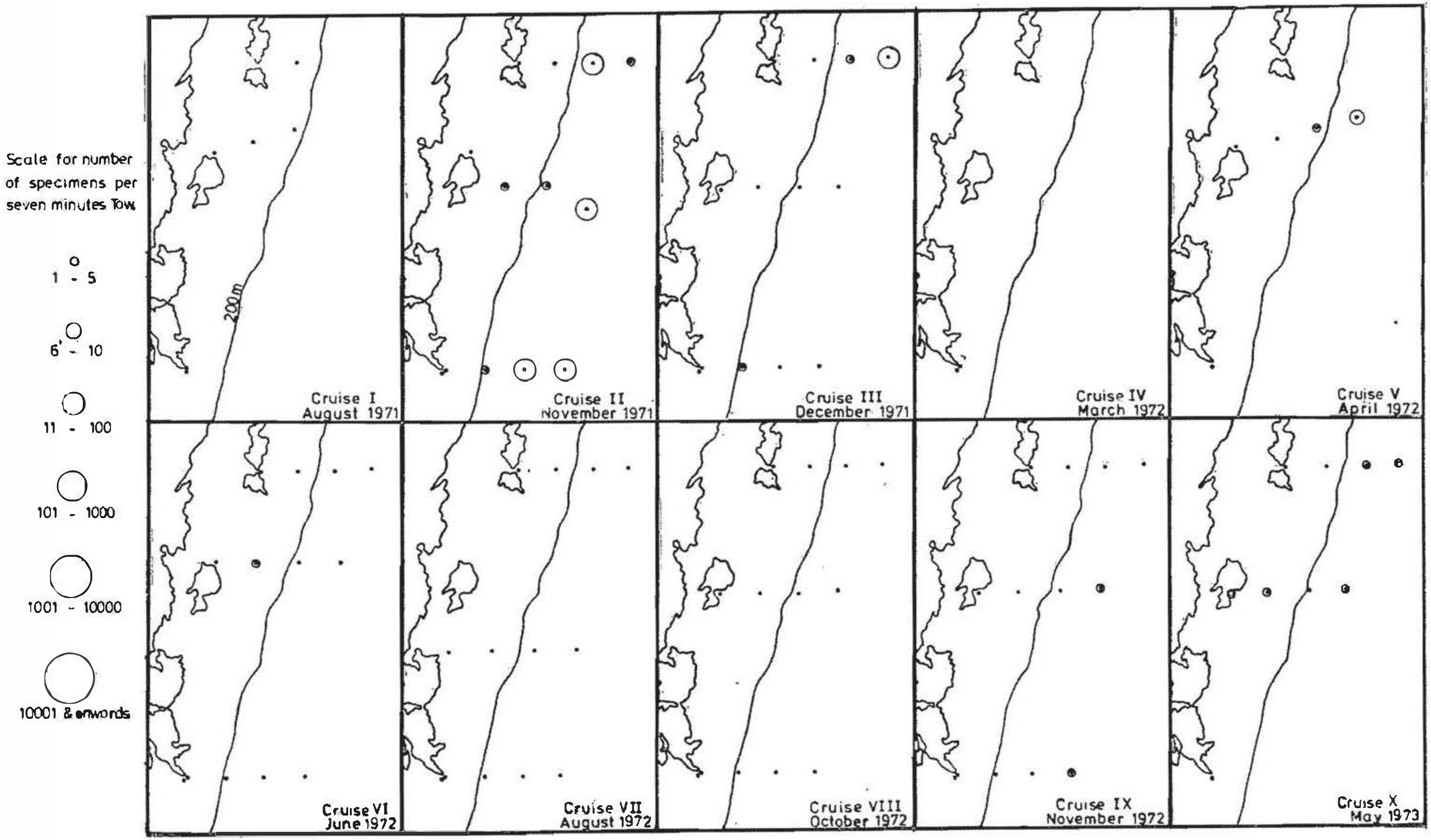

Fig. 37 Distribution of Nematoscelis megalops, Cruises I - X.

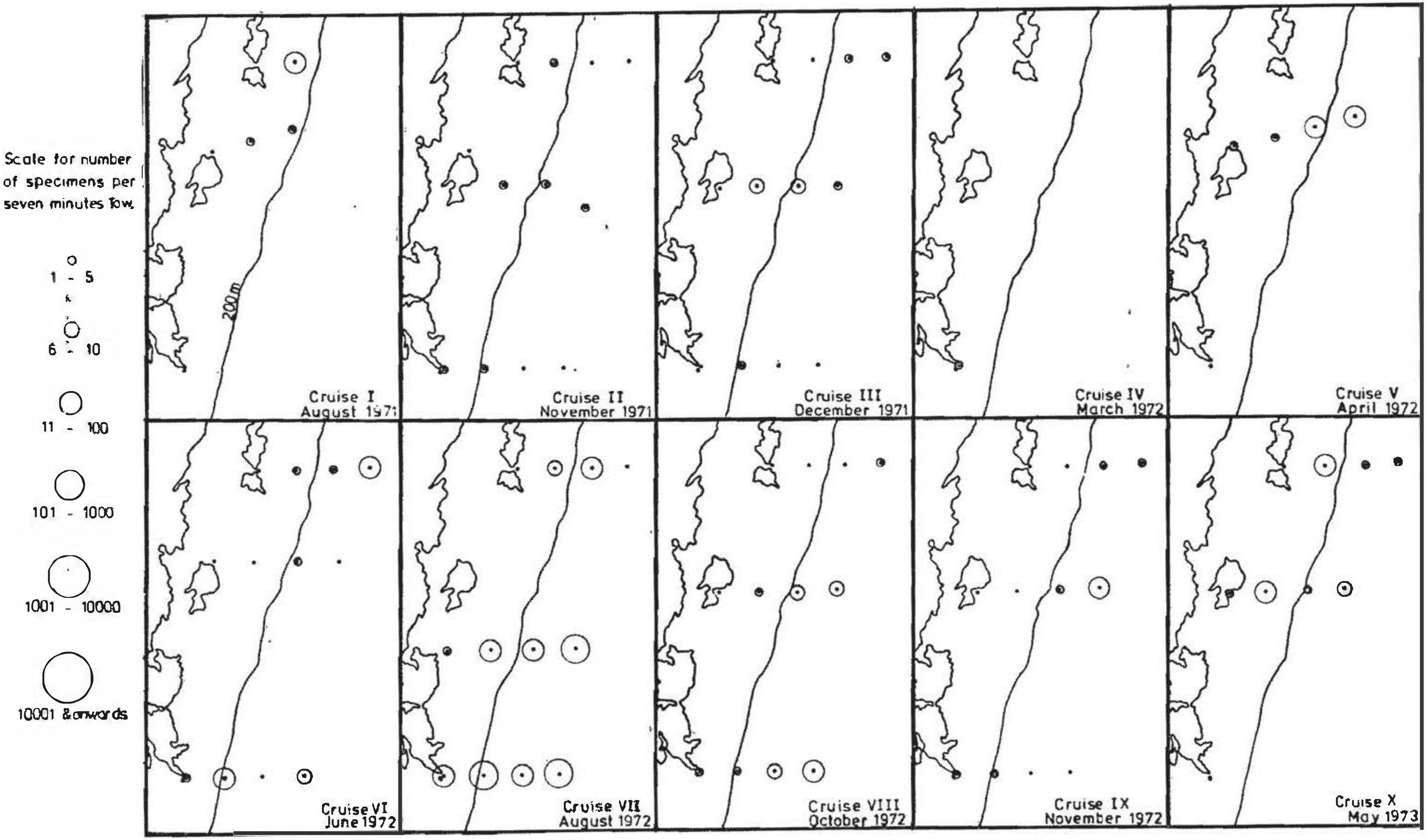

Fig. 38 Distribution of *Thysanoessa gregaria*, Cruises I - X.

affinity to Central Tasman and southwest Tasman water masses. In the present study it showed no tendency to favour any p particular environment in terms of temperature and salinity (Fig. 34).

CHAETOGNATHA

Eukrohnia hamata

Only a single specimen was captured at Station 70.

/c Pterosagitta draco

Occurrence............... Fig. 39.

A widespread, rare to common species taken during Cruises I, II, III and IV. From Cruises V to VII, it was found only in coastal waters. It appeared in northern and middle transect stations, rare to common in oceanic stations and rare in the coastal waters, during Cruise VIII. During Cruises IX and X it was widespread, occurring in almost all the oceanic stations, a rare to common constituent in Cruise IX and rare in Cruise X.

It is a cosmopolitan warm water species (Alvarino, 1964). According to Thomson (1947) it is a cold water tolerant tropical sub-tropical species. In the present study, although it was found together with sub-Antarctic cold water species (e.g. with S. gazellae) during the spring cruises, it appeared to prefer warm, high salinity sub-tropical waters (Fig. 40) which agrees with Thomson's (1947) findings.

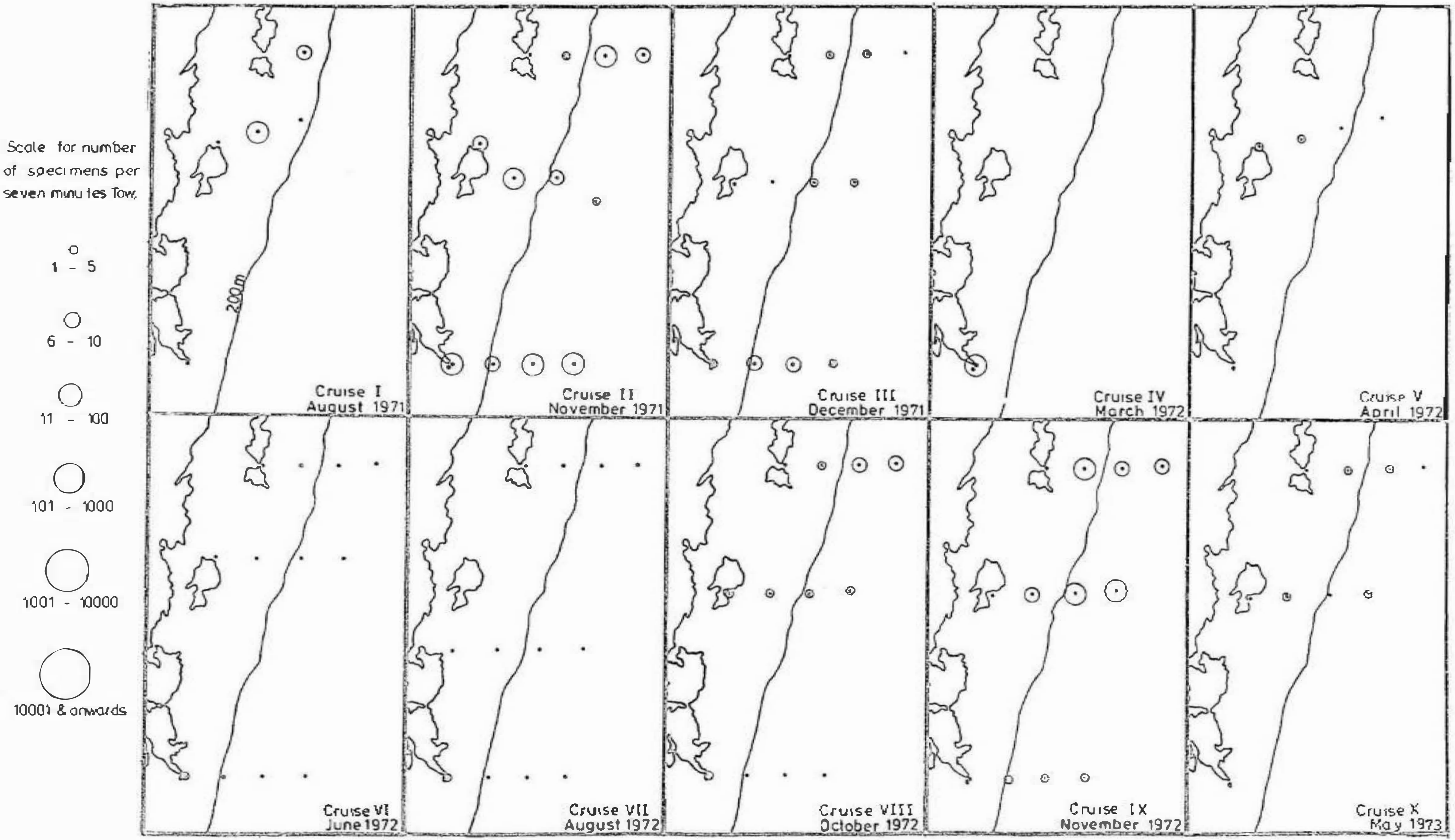

Fig. 39 Distribution of Pterosagitta drago, Cruises I - X.

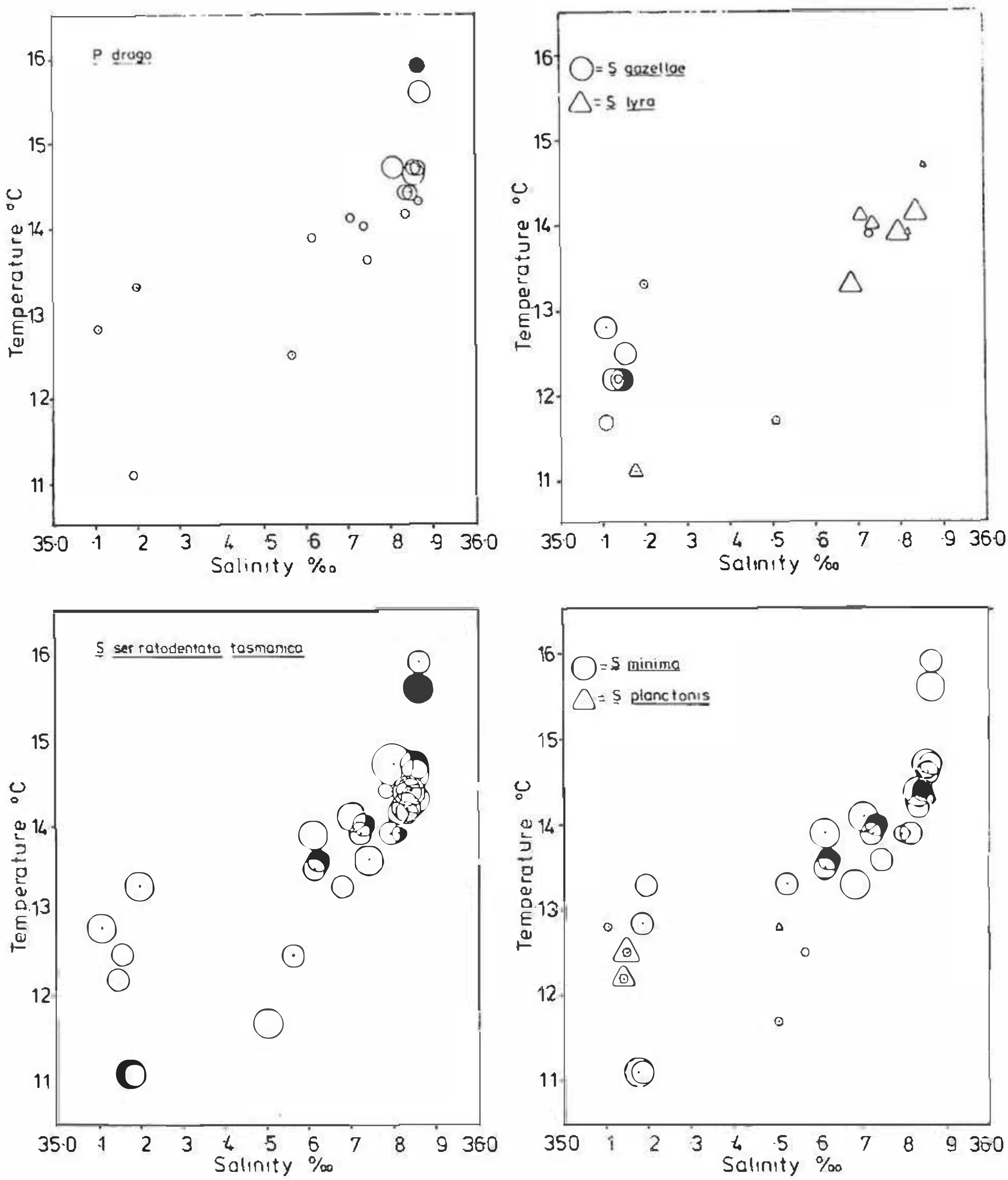

FIG. 40 - TEMPERATURE-SALINITY-PLANKTON DIAGRAMS FOR PTEROSAGITTA DRAGO, SAGITTA GAZELLAE, SAGITTA LYRA, SAGITTA SERRATODENTATA TASMANICA, SAGITTA MINIMA AND SAGITTA PLANCTONIS

Sagitta gazellae

Occurrence............... Fig. 41.

Occurred in a number of stations, in both coastal and oceanic waters, rare to common in number, during late winter to early summer cruises (Cruises I, II and III) of 1971. It appeared again, the number taken being larger, during late winter cruise (Cruise VII) of 1972. During Cruise VIII it occurred only in the middle and southern transect, mainly in common constituents. Only one specimen was captured at a coastal station during Cruise IX.

This species is an endemic species of sub-Antarctic, Antarctic waters, the northern limit being as far as sub-tropical convergence (David, 1955, 1958, 1965; Alvarino, 1965). Bary (1959) used it as an "Intolerant southern sub-Antarctic" indicator species in the southern New Zealand waters. Bradford (1972) found it to occur in considerable numbers from November to January off the central east coast of New Zealand. The presence of this species in the area no doubt indicates the presence of sub-Antarctic water elements. Its recurrence in 1972 cruises confirms that the intrusion of sub-Antarctic water into the study area is seasonal. As expected, its preference to cold, low salinity sub-Antarctic water can be clearly seen (Fig. 40).

Sagitta lyra

Occurrence............... Fig. 41.

Occurred sporadically during Cruises II and III in the coastal waters. It was common in the sole station operated in Cruise IV and was taken at two coastal stations during Cruise V. During Cruises VI and X it was taken in a number of stations in

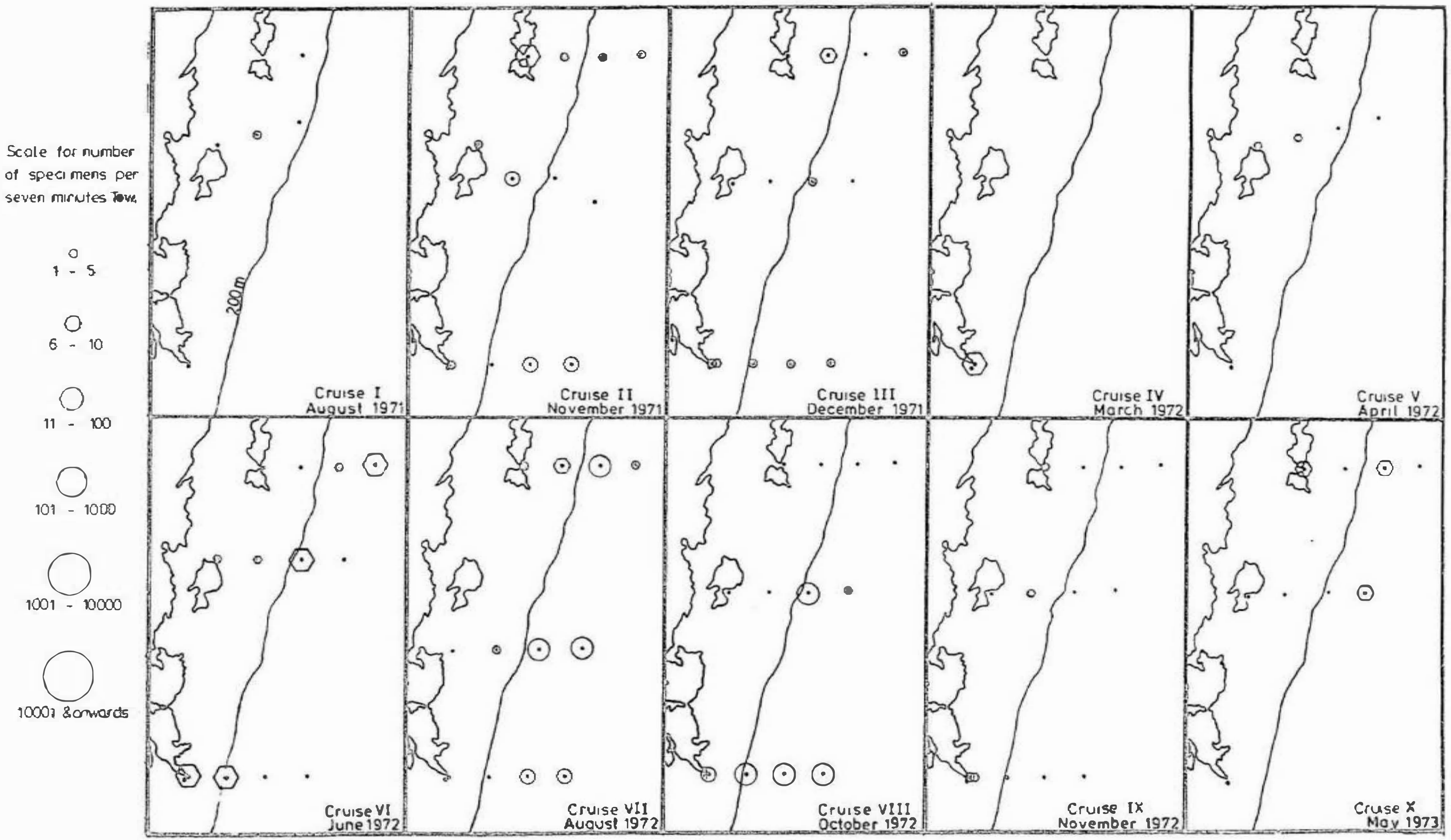

Fig. 41 Distribution of *Sagitta gazellae* (◯) and *Sagitta lyra* (⬡), Cruises I - X.

common constituents. However, during Cruises VII and IX it was taken only in the coastal waters.

It is a tropical, sub-tropical, warm water species (Alvarino, 1965). According to Alvarino (1965), S. lyra reported by Thomson (1947) is S. gazellae. Thomson (1947) clearly noted that he considered S. gazellae as a synonymy of S. lyra. As such, the ecology and distribution given by him could be for both species. Shead (1965) followed Thomson's (1947) synonymy and regarded S. lyra as having the affinity to central Tasman and southwest Tasman water masses. Again he could be referring to S. gazellae or to both species. In the present study area, it was found in warm months, associated with sub-tropical species, in oceanic water, but during other months it occurred only in coastal waters. The temperature - salinity Plankton diagram clearly showed that it favoured warm, high salinity sub-tropical water (Fig. 40).

Sagitta hexaptera

A rare species, occurred at five stations - Stations 4, 29, 32, 73 and 82.

Sagitta enflata

A single specimen was captured at Station 73. Thomson (1947) considered it as a typical warm-water species and that the presence of it, south of 38°S would indicate an unusual southward penetration of warm water.

<u>Sagitta serratodentata atlantica</u>

Only two specimens were captured at Station 10.

<u>Sagitta serratodentata tasmanica</u>

Occurrence .... Fig. 42.

Widely distributed species, occurring in common to abundant numbers in all cruises. Cruise VII was the only cruise in which it was found only once in an oceanic station.

It is an oceanic epiplanktonic species, typical of sub-Antarctic waters in the southernmost part of the Indian and Pacific Oceans (Alvarino, 1965). Bradford (1972) encountered this species to be abundant, occurring throughout the year in the central east coast of New Zealand. Bary (1959) found it to indicate northern sub-Antarctic waters in the southern New Zealand waters.

The occurrence of this species in the study area appeared to be similar to that of Bradford's (1972) findings. It was found to have no preference to environmental conditions in regard to temperature and salinity (Fig. 40).

<u>Sagitta planctonis</u>

Occurrence................. Fig. 43.

Occurred in a number of stations during Cruise II in common constituents. It was rare and taken at only two stations in Cruise III. During Cruise VIII it was common to very common in number, found in the southern transect stations. A specimen was also captured at a coastal station in the northern transect stations during the cruise. In Cruise IX a few specimens were taken at only one oceanic station.

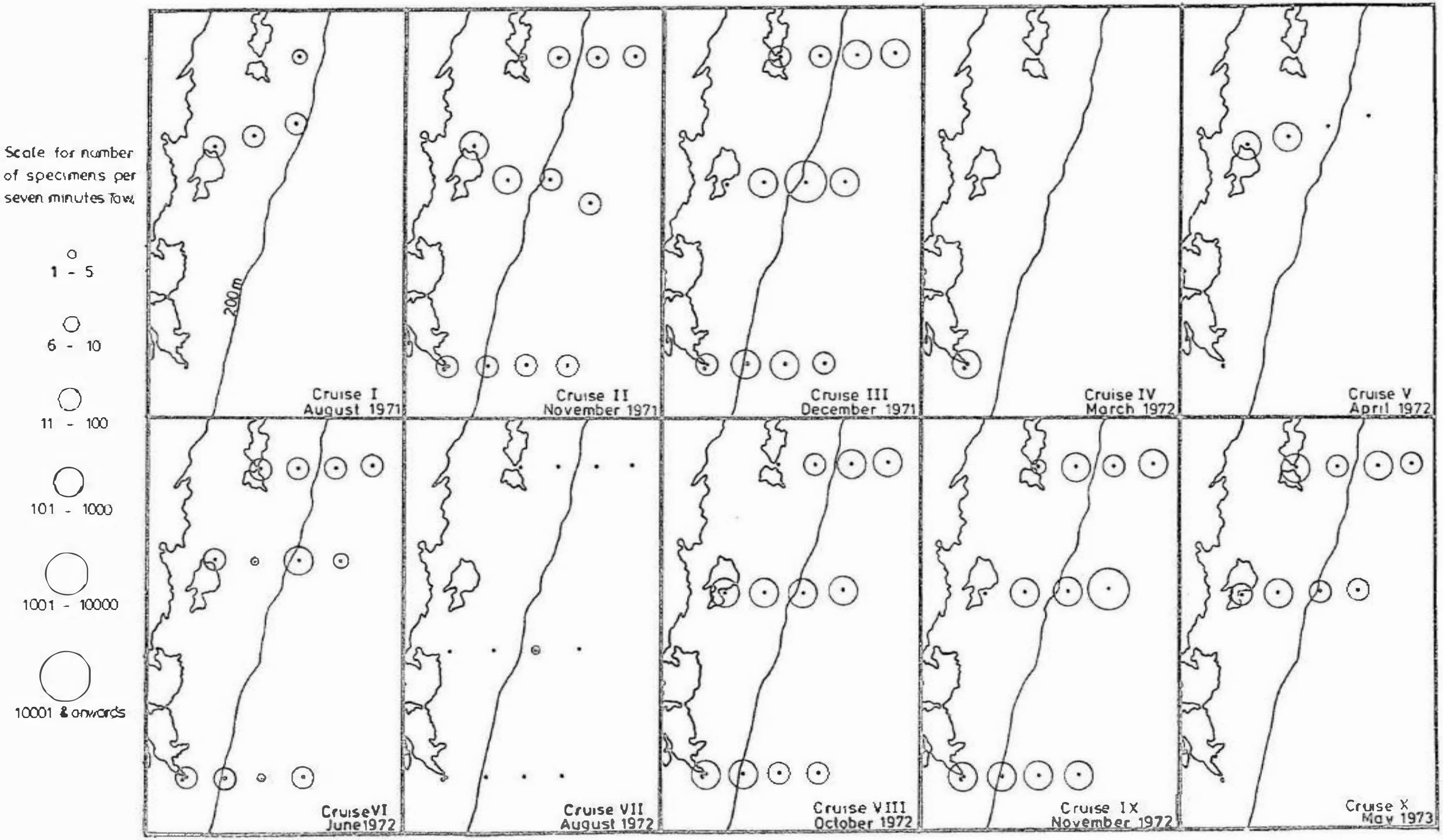

Fig. 42 Distribution of Sagitta serratodentata tasmanica, Cruises I - X.

It is a surface living form found in the Tasman Sea and off northeastern waters of New Zealand in the Pacific Ocean (David, 1956). According to Alvarino (1965) in the Pacific Ocean, it is distributed along the southernmost part, extending into sub-antarctic waters. Sheard (1965) found it to have an affinity to central Tasman and southwest Tasman water masses. In the present study area, it was taken usually together with cold water, sub-Antarctic species. It was also found to favour cold, low salinity sub-Antarctic waters (Fig. 40).

Sagitta minima

Occurrence..................... Fig. 43.

A widespread species, usually found as a common to very common constituent. Although it is a known oceanic species, the number found in oceanic as well as in coastal water was irregular. Its tolerance to low salinity was unusual as it was found in the samples taken at the upper region of the Derwent River, where the salinity was as low as 13.10‰ (see Section III). Alvarino (1965) noted that it is a species typical of regions of mixing of waters - neritic and coastal - or of different water masses. However, in the oceanic waters in the area, it seemed to prefer warm, high salinity water (Fig. 40).

TUNICATA

PYROSOMIDA

Pyrosoma atlanticum

Occurrence...................... Fig. 44.

It occurred in a number of stations as rare to common constituents during Cruise II. It appeared again from early

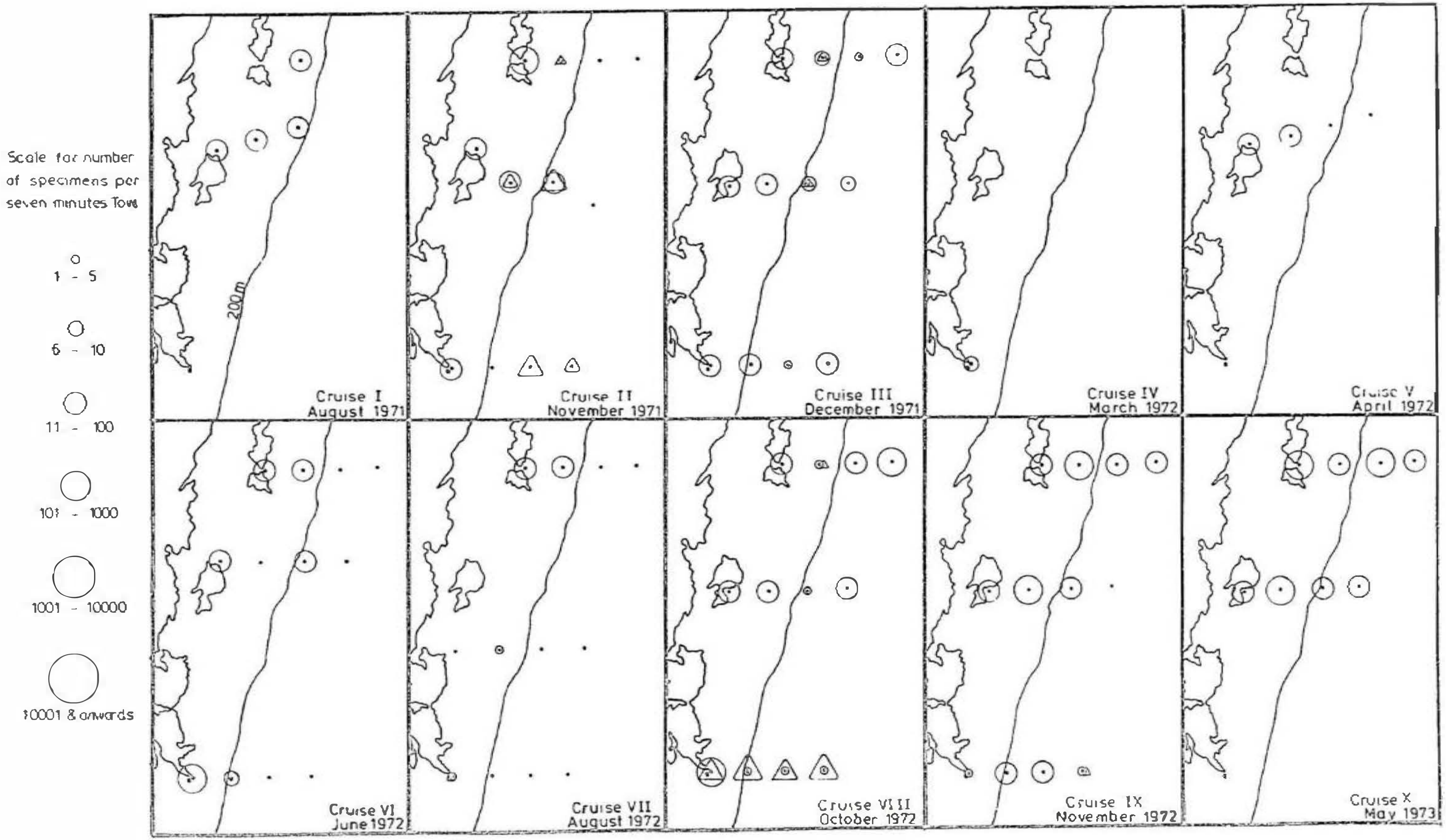

Fig. 43 Distribution of Sagitta planctonis (△) and Sagitta minima (◯), Cruises I - X.

autumn to early winter (Cruises IV to VI) cruises. None were found in the remaining cruises.

Dakin and Colefax (1940) recorded this species off the east coast of New South Wales. Thompson (1948) found it to be common between southern part of Queensland coast to the south of Tasmania and off the east of Tasmania, it is said to occur during all seasons of the year. The findings from the present study seem to contradict Thompson (1948). It seemed to occur usually in warm months.

Thetys vagina

A few specimens were taken at three stations - Stations 38, 40 and 42 - during Cruise VI.

Iasis zonaria

A few specimens were captured at Stations 7, 20 and 29.

Thalia democratica

A few specimens were encountered at Stations 67, 76 and 78.

Ihlea magalhanica

Occurrence............... Fig. 44.

Taken at a few oceanic stations as rare to common constituents in Cruise II. A few specimens were also captured at the sole station operated during Cruise IV. During Cruise IX, it was common to abundant in a number of stations.

Kott (1957) used it as an indicator of surface offshore Tasmanian waters. Thompson (1948) encountered the species to the north as far as southern Queensland coast and to the south as far as the east of Tasmania. He found it to be most common at the east coast of Tasmania, the maximum occurrence being during October and February. The appearance of it in the study area agreed with Thompson (1948).

Salpa fusiformis

Occurrence.................. Fig. 44.

Occurred in common constituents at the sole station operated in Cruise IV. It was encountered again at two stations, rare at coastal and common at oceanic stations, during Cruise V. In Cruises VI and IX, it was found at one station each in common constituents.

Thompson (1948) found this species to be widespread from the south of the Great Barrier Reef to the south of Tasmania, on the east coast of Australia. An abundant number was taken in the Storm Bay area in February and March 1972 (see Section III). Although it occurred sporadically in the present study, finding an abundant number at Storm Bay suggests that it is a common species in the area. The absence of it in the area could possibly be due to the lack of sampling in warmer months (January to April).

Salpa maxima

Occurrence................. Fig. 44.

Taken only during Cruise VI at a few oceanic stations in common to abundant constituents.

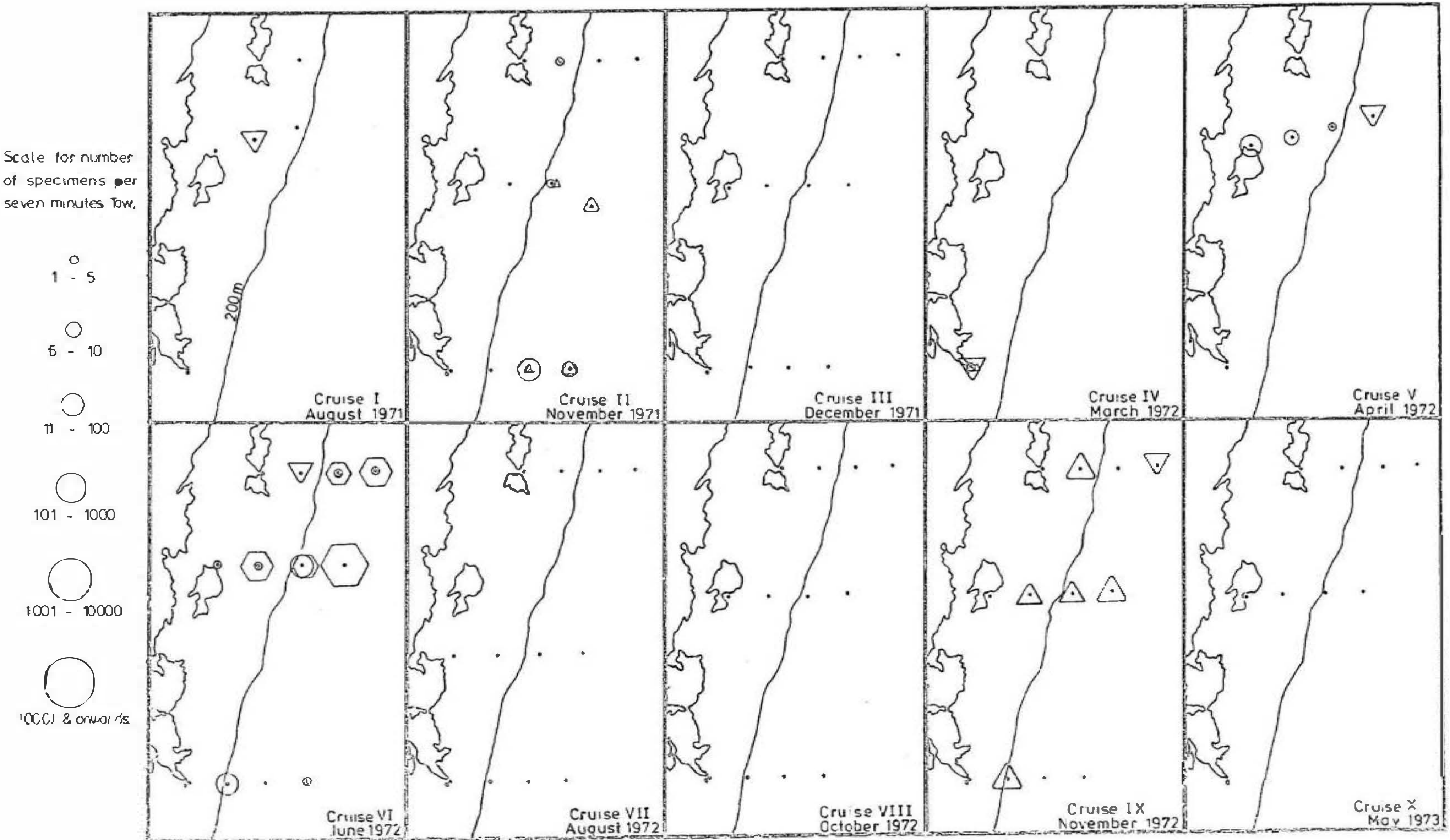

Fig. 44 Distribution of Pyrosoma atlanticum (○), Ihlea magalhanica (△), Salpa fusiformis (▽) and Salpa maxima (●), Cruises I - X.

Thompson (1946) found it to be common in the southeast coastal waters of Australia, as far south as the east of Tasmania. In the present study area it dominated the plankton sample when it occurred.

SPECIES DIVERSITY

The number of species found in the coastal and oceanic waters in the area depends on the type and the intensity of oceanic waters which flows along the east coast. Generally, the number of species was greater at the coastal shelf compared with those in the oceanic waters. A simple species diversity chart for all cruises is given in Figure 45.

The maximum number of species was found in the coastal shelf waters, as can be seen, during Cruises I, II, III and IX. The number decreases in the nearshore coastal and oceanic stations. During these cruises it was probably due to low intensity intrusion of oceanic waters into the coastal region. However, during Cruises V, VI, VII and VIII, probably due to the high intensity intrusion of oceanic waters, the coastal shelf water was pushed closer to the shore, which accounts for the greater number of species in the nearshore coastal stations.

The greater number of species in the coastal shelf waters was due to the combined number of species left behind by a water mass when it retreated after its invasion into the area and the number of species brought in by the new invading water mass. A good example can be observed between Cruises VI and VII and between Cruises VIII and IX. During Cruise VI the area was dominated by warm, sub-tropical waters. This sub-tropical water mass was replaced by sub-Antarctic waters prior to Cruise VII. However, in the coastal waters, sub-tropical species were still found, although the water mass had retreated from the area. A similar case can be seen between Cruises VIII and IX. In this case, sub-Antarctic cold water species were left behind in the coastal water, when the area was invaded by sub-tropical waters during Cruise IX.

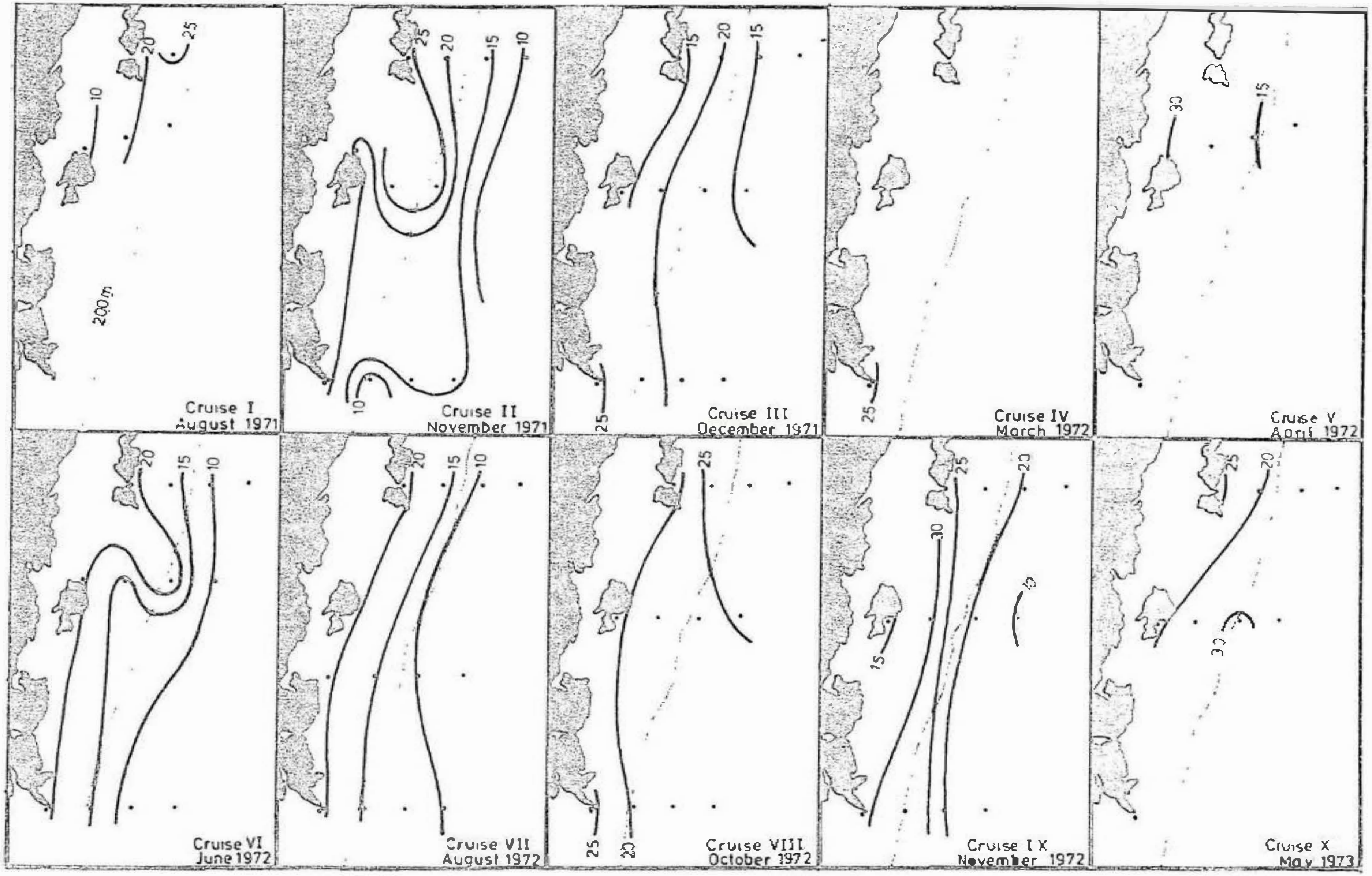

Fig.45 Number of species of zooplankton, Cruises I - X.

Bowman (1971), in his studies on the distribution of Calanoid Copepods, found that there were greater numbers of species at the oceanic stations compared with the smaller numbers in shelf waters and the very small numbers along the coast. Bowman's findings and the results in the present study, were not comparable due to the geographical nature of the areas. Bowman's area was sub-tropical, and had a wide Continental Shelf (< 200m depth) between approximately 40 to 100 miles, whereas the present study area is a mixing region between sub-tropical and sub-Antarctic waters, with approximately 10 to 30 miles of Continental Shelf. Most of the stations operated by Bowman were on the Continental Shelf waters. In the present study, half of the stations were operated in the Continental Shelf and the remaining half in the oceanic region. However, should there be a few more stations operated closer to the shore the species diversity between inshore and offshore on the shelf waters could be similar to that of Bowman. This can be seen during Cruise I and Cruise III, where smaller numbers of species were found in the stations close to shore.

ZOOPLANKTON SPECIES GROUPS IN RELATION TO ENVIRONMENTAL CONDITIONS OFF THE EAST COAST OF TASMANIA

INTRODUCTION

The presence of sub-tropical and sub-antarctic zooplankton species off the east coast of Tasmania in large numbers suggests that these water masses have a strong influence in the area. This was recognised by Wyrtki (1960, 1962) from the physical and chemical studies on the area.

There was also a marked inshore-offshore zonation in distribution of coastal and oceanic species. Certain species were restricted to coastal whereas others were found only in oceanic waters.

The main aim of this study is to identify these species association and the association of stations that had similar fauna and to determine species which could be useful as biological indicators of hydrological conditions.

The biological indicator species concept has been recognised and used by many workers, namely, Bigelow (1926), Meek (1928), Russell (1935, 1939), Thomson (1947), Fraser (1952), Kott (1957), Bieri (1959) and Lebrasseur (1959).

The use of temperature-salinity-plankton (TSP) diagram to determine indicator species in a faunistically and hydrologically little known area was suggested and used by Bary (1959). This method was later successfully used by Bary (1963a, b & c, 1964), Sherman (1964) and Cross and Small (1967).

Thomson found that in the region along the Eastern Australian coast, the area between Flinders Island and Jervis Bay is the only region where Chaetognaths can be used as indicators. The presence of Sagitta serratodentata tasmanica and cold-water form of Sagitta lyra (S. gazellae) north of the area would indicate northward penetration of colder waters from Tasmanian region, conversely, the discovery of Sagitta enflata, Sagitta robusta and Sagitta ferox south of the region would indicate an unusual penetration of warm water. Similarly, Kott defined the southeastern coastal waters of Australia by zooplankton indicator species. Russell (1935) showed that if two indicator species of different water mass origin were found together, they were indicative of mixed water.

However, a statistical approach to the indicator species concept on marine plankton has not been applied until very recently. Statistical methods based on presence or absence of species as suggested by Fager (1957) have been used by Fager and McGowan (1967), Sheard (1965) and Bowman (1971). Methods based on abundance, using principal component analysis was used by Cassie (1963). ~~Both~~ All previous works deal only with the grouping of species by association analysis. There was no attempt in marine zooplankton studies to determine the association of species as well as stations and to find the associated species group characterizing the associated station-groups, although there were a few studies on marine benthos communities (Stephenson, Williams and Lance, 1970; Stephenson and Williams, 1971).

In the present study species are chosen partially based on the temperature-salinity-plankton diagram and the grouping of species as well as stations at which they occur, using computer program called DIVINFRE.

MATERIALS AND METHODS

The species used was collected during 10 cruises off the east coast of Tasmania from August, 1971 to May, 1973, where 89 stations were operated. The individual systematic accounts and distribution was given in Section I and the early part of this Section, respectively. Thirty five zooplankton species consisting of 23 Copepods, 3 Euphausids, 5 Chaetognaths and 4 Pelagic Tunicates were selected for the analysis. The species selected for the analysis satisfy the following criteria: -

i. their taxonomic status is clear,

ii. they are readily distinguishable,

iii. they show some preferences to certain water environment - either geographical preference, e.g. coastal or oceanic, or preference to temperature and salinity (oceanic water masses),

iv. their vertical range falls within the depth of sampling and,

v. they occur at least 4 times and not more than 66 times in moderate numbers. The number of occurrences correspond to 5 and 75% of the total number of stations operated. This was chosen because it was felt that since binary data will be used for the analysis, the species which occurred more than 75% would be unfavourable.

The method used for the analysis of species and station grouping was the program DIVINFRE (A.D. Weif, updated, Mayo,1972). The program produces a divisive classification on binary (presence/absence) data, including re-allocation. This program was carried out at Canberra on the Cyber 76 computer. The process, according to Mayo (1972) is a modification of the program DIVINF of Lance and Williams (1968) which performs a monothetic divisive classification using an information statistic on binary data. The initial divisions carried out by these programmes are identical. This program includes a polythetic re-allocation procedure. The re-allocation procedure (Mayo) is as follows:-

RE-ALLOCATION PROCEDURE

At each pass, each individual I is taken in turn and checked to see which group it most resembles. For pass (n+1) the group labelled G consists of those elements found to resemble the group which was labelled G on pass n. (If the original classification was any good, of course, most elements are re-allocated back to their original groups). The procedure stops after a specified number of passes (taken as 10 unless indicated otherwise), or if successive passes produce no change in groups. At this stage the probabilities may be printed.

The resemblance of an individual I to a group is measured thus :

$$S = \sum_{A} \log P(A, G) + \sum_{A'} \log \; 1 - P(A', G)$$

where the matrix P(A, G) whose elements are the proportion of group G, which have the attribute A; A denotes an attribute possessed by I and A' denotes an attribute lacked by I.

When P or (1-P) vanishes, the corresponding term in the sum is taken as log ($\frac{1}{2}$N) where N is the total number of non-zero individuals in the sample. We take the group with maximum S to be one most like the individual I. (Note that since S 0, this menas the S closest to zero).

The element I is temporarily removed from its present group before the comparison is made. Otherwise, especially if the group is small, element I will be found to resemble its own group, even when the other members are very different.

Groups whose members have all migrated are omitted from the comparisons, as is the "renegade group". The latter is formed from elements which insufficiently resemble any of the existing groups, as measured by their maximum S falling below a specified level. Groups consisting of a single element are automatically put into the renegades, as are those which would otherwise oscillate back to their group of the previous pass. This is designed to prevent a pair of similar elements chasing each other, and has eliminated most of this nuisance.

SPECIES GROUPS

Six species groups were obtained from the analysis (Table 1). The sixth "renegade group" which contain only one species (*Acartia danae*) is formed from the elements which insufficiently resemble any of the existing groups. This group, as it has no affinities to any other group, is omitted from further consideration.

The first group - Group I, consisted of four species, 3 Copepods and 1 Chaetognath. Apart from the Chaetognath, the remaining species in the group are known coastal species. The Chaetognath, *Sagitta minima*, according to Alvarino (1965) is a species typical of mixing waters - neritic and coastal or of different water masses. In the present study it was commonly distributed in the coastal and oceanic sub-tropical waters. This group is termed as coastal indicator species-group.

Species contained in Species-Group II, III and IV are, from their previous distributional records, known to have affinities to oceanic, sub-tropical waters. This was confirmed by their preference for warm, high salinity waters (see TSP diagram for the species). All three Species Groups can be generally termed as sub-tropical species-groups.

Species-Group II consisted of 8 species - 6 Copepods, 1 Chaetognath and 1 Euphausid. The species comprising the group were widely distributed in the coastal and oceanic sub-tropical waters. Among the species in the group, *Nyctiphanes australis* is the only coastal species. Most of the remaining species are common in the waters off New South Wales coast. Due to their general distributional nature in the area, the group is termed nearshore sub-tropical indicator species-group.

Eight species, 2 Copepods, 2 Euphausids and 4 Pelagic Tunicates, comprising species group III were mainly found in the offshore oceanic sub-tropical waters. They were also found to have a narrow range of tolerance to temperature and salinity. As such, the group is termed offshore sub-tropical species-group.

The species in the Species Group IV, although sub-tropical in nature, was found to have a wide range of tolerance to temperature and salinity (see T.S.P. diagrams for the species). The group consisted of 3 Copepods and 1 Chaetognath. The group is termed tolerant oceanic sub-tropical species-group.

Species Group V which is made up of 10 species - 8 Copepods and 2 Chaetognaths, is termed sub-antarctic indicator species-group because of their previous distributional and habitat records. Apart from 1 Copepod species - Eucalanus attenuatus, a sub-tropical species which had also been recorded in sub-antarctic waters, the remaining species are known inhabitants of sub-antarctic waters or species which showed preference to such waters.

It seemed the three species, S. minima, N. australis and E. attenuatus are not in natural association with their corresponding species group. This was later confirmed by their constancy and fidelity to their station-group (see page and the possible reason will be discussed in the general discussion. Due to this, the three species are omitted from their species-group and cannot be used as an indicator species.

An indicator species is one that is so characteristic of a particular biotope that occasional records within the normal geographical range of another are taken to indicate physical translocation of one biotope relative to the other.

<table>
<tr><td>SPECIES-GROUP I

Paracalanus parvus (C)
Centropages australiensis (C)
Acartia clausi (C)
(Sagitta minima) (Ch)</td><td colspan="2">Coastal</td></tr>
<tr><td>SPECIES-GROUP II

Calanus minor (C)
Neocalanus robustior (C)
Pleuromamma abdominalis (C)
Pleuromamma gracilis (C)
Candacia bipinata (C)
Oncea media (C)
Sagitta lyra (Ch)
(Nyctiphanes australis) (E)</td><td>Sub-Tropical
near-shore</td><td rowspan="3">Sub-Tropical
(Oceanic)</td></tr>
<tr><td>SPECIES-GROUP III

Eucalanus crassus (C)
Leptocalanus plumulosus (C)
Euphausia recurva (E)
Nematoscelis megalops (E)
Pyrosoma atlanticum (T)
Ihlea magalhanica (T)
Salpa fusiformis (T)
Salpa maxima (T)</td><td>Sub-Tropical
off-shore</td></tr>
<tr><td>SPECIES-GROUP IV

Eucalanus elongatus (C)
Rhincalanus nasutus (C)
Oncaea vanusta (C)
Pterosagitta drago (Ch)</td><td>Sub-Tropical
tolerant</td></tr>
<tr><td>SPECIES-GROUP V

Neocalanus tonsus (C)
Eucalanus longiceps (C)
Calocalanus contractus (C)
Calocalanus styliremis (C)
Clausocalanus laticeps (C)
Euchirella rostrata (C)
Euchirella rostromagna (C)
Sagitta gazellae (Ch)
Sagitta planctonis (Ch)
(Eucalanus attenuatus) (C)</td><td colspan="2">Sub-Antarctic
(Oceanic)</td></tr>
<tr><td>SPECIES-GROUP VI (renegade group)

Acartia danae (C)</td><td colspan="2">No affinities</td></tr>
</table>

C - Copepods
Ch - Chaetognaths
E - Euphausids
T - Pelagic Tunicates

The species in parenthesis are not in natural association with the species-groups and are to be omitted as indicators from the group (see text).

TABLE 1. ZOOPLANKTON INDICATOR SPECIES-GROUPS AND THEIR APPROPRIATE WATER MASSES.

STATION GROUPS

It has been established by hydrological data that the area was influenced by two oceanic water masses, namely sub-warm, high salinity sub-tropical and cold, low salinity sub-antarctic waters. Geographically the stations can be divided into two areas - shallow water zone (< 200m) and deep water zone (>200m).

Twelve station groups were obtained from the station grouping from the DIVINFRE analysis (Table 2). One can clearly see from the distribution of the station groups the two major groups of stations - the coastal station group and oceanic station group (station group 1 to 3 and 4 to 12 respectively) (Fig. 46 and 47). However, a detailed study is needed to verify the relativity between the station groups. This can be done by the two-way table - the relationship between the station-group and species-group.

Station-Groups

Group 1	3/23-24/28/77.	COASTAL
Group 2	4/16/32-34/41/45-46/53/56-57/69/81/84-85/88-89.	
Group 3	1-2/5/11-12/17-18/58/64-65/68/70.	
Group 4	62/66-67/71/76/80/87.	OCEANIC
Group 5	42-43.	
Group 6	30-31/35/37-40/44/47/52/83/86.	
Group 7	10/29/72-73/75/78-79/82.	
Group 8	6/9/13/74.	
Group 9	7-8.	
Group 10	14-15/19-22/25-27/63.	
Group 11	59-61.	
Group 12	36/48-51/54-55.	

TABLE 2. STATION-GROUPS WITH THE TWO MAJOR GROUPS OF THE STATION-GROUPS

ANALYSIS OF SPECIES-GROUP/STATION-GROUP COINCIDENCES

A standardized two-way table (Table 3) using 5 species-groups and 12 station-groups was prepared (Stephenson, Williams and Lance, 1970). The standardizing process is as follows:-

> The total number of occurrences of all the species of the species-groups in all the stations of the station-groups were entered. The table was then first standardized by rows, reducing each entry to the value per 100 species, then by columns, reducing each column standardized entry to its value per 100 stations.

The resulting double standardized values were entered into the final 5 x 12 table (Table 3), having arranged the species-groups and station-groups to their nearest neighbour. Twenty percent was chosen arbitrarily as a significant percentage for a cell value using the following criteria:-

> The three stations in station-group 11, from the hydrological aspect can be considered as sub-antarctic (temperatures $<13^{\circ}C$; salinity $< 35.20‰$). This was confirmed by the very high percentage (99.49 - 99.95%) of sub-antarctic indicator species-groups (Species-group V). Had the percentage lower that 20% been chosen, the station-group would have been characterized in addition to Species-group V (sub-antarctic) by Species-group IV (tolerant sub-tropical). It was found that, although 20% is extremely good, the values just lower than this cannot be ignored as some information can still be obtained from them. The values higher than 20% have been encircled in the tables for increased clarity.

A

Species-Group	Station-Groups 1	2	3	4	5	6	7	8	9	10	11	12
I	69	30	29	19	0	4	16	8	0	10	5	0
II	6	38	13	14	60	35	18	8	0	2	0	9
III	0	11	9	24	40	48	29	54	50	12	0	0
IV	19	16	15	25	0	7	29	23	21	43	19	0
V	6	5	34	18	0	6	7	8	29	33	76	91

TABLE 3. Standardized species-group/station-group coincidence table in percentages (values of 20% or more are encircled).

B

Species-Group	Station-Groups 1	2	3	4'	5'	6'
I	69	30	29	13	8	3
II	6	38	13	22	2	3
III	0	11	9	35	21	0
IV	19	16	15	21	38	13
V	6	5	34	11	32	81

TABLE 4. Standardized species-group/station-group table in percentages, having similar station-groups from Table 3 combined - former station-groups 4, 5, 6, 7 and 8 become station-group 4'; former station-groups 9 and 10 become station-group 5'; and former station-groups 11 and 12 become station-group 6'. (Values of 20% or more are encircled).

Strong interspecific relations between Species-groups II, III and IV have been discussed (see Species-Groups). With this information in mind, one can determine the relationship between the station-groups. Basically, the 12 station-groups can be divided into two groups - station-groups characterized at least by species-group I and the remaining station-groups. This would be between station-groups 1 to 3 and station-groups 4 to 12, respectively. In the first group of station-groups (groups 1, 2 and 3), station-group 1 is characterized by high value of species-group I; station-group 2 is characterized by species-group I and II; and station-group 3 is characterized by species-group I and V (Table 3). Station-groups 4 to 8 are characterized by at least two of the three species-groups - species-group II, III and IV. Station-groups 9 and 10 are characterized by all three or at least two of species-groups III and IV and species-group V. Station-groups 11 and 12 are characterized solely by species-group V.

As the relationship between the station-groups are clearly seen by the characterizing related species-groups, another two-way table is prepared combining the related station-groups, namely - station-groups 4, 5, 6, 7 and 8; 9 and 10; 11 and 12, to have a clear general pattern, resulting in a new 5 x 6 table (Table 4). Some information (will be discussed later) would be lost in the process but a clear general understandable pattern of distribution of station-groups can be obtained. As expected, the station-group 4' (former station-groups 4, 5, 6, 7 and 8) is found to be characterized by species-groups II, III and IV; station-group 5' (former station-groups 9 and 10) is characterized by species-group III and IV; station-group 6' (former station-groups 11 and 12) is characterized solely by species-group V (Table 4).

To determine the extent to which individual species may have diagnostic value, the following two types of measure were used. These are constancy and fidelity. Constancy is a measure of the extent to which a given species may be expected to occur in similar environment. Fidelity is a characteristic of a given species which shows a degree of exclusiveness towards a group of stations. Thus a "constant" species may have a wider ecological tolerance and occur in several associations, whereas a species with a high degree of "fidelity" has a narrow ecological tolerance and only occurs in an association (Kershaw, 1971). The simple method employed by Stephenson, Williams and Lance (1970) to measure constancy and fidelity was used here. The results are given in Table 5.

SPECIES-GROUPS/STATION-GROUPS RELATIONSHIP TO ENVIRONMENTAL CONDITIONS

The station-groups agree very well with the hydrological condition and the geographical nature of the area (Fig. 46).

The stations in the station-groups 1, 2 and 3 are situated in the coastal shallow water areas. Station-group 1 is very strongly characterized by species-group I (coastal) which consists of 4 species. The three species, *Paracalanus parvus*, *Centropages australiensis* and *Acartia clausi* have moderately high fidelity and very high constancy. As expected, *Sagitta minima* has low fidelity and very high constancy.* This confirms that *S. minima* is not in natural association with the remaining species in the group. The area occupied by the station-group can be regarded as pure coastal.

Station-group 2 is characterized not only by the species-group I (coastal) but also by species-group II (sub-tropical). This species-group is also a characteristic species-group of station-groups 5 and 6. The species-group comprises 8 species. Except for *Nyctiphanes australis*, which is a known coastal species, having a low fidelity and constancy, the remaining species have between high and moderately high fidelity and low to very high constancy (Table 5). A notable change in the fidelity and constancy of the species is observed in the results from the combined (5 x 6) table (Table 4). The most obvious change is in *Calanus minor* which previously had high fidelity

* 1-25% very low	61-80% moderately high
26-50% low	81-100% very high
51-60% high	

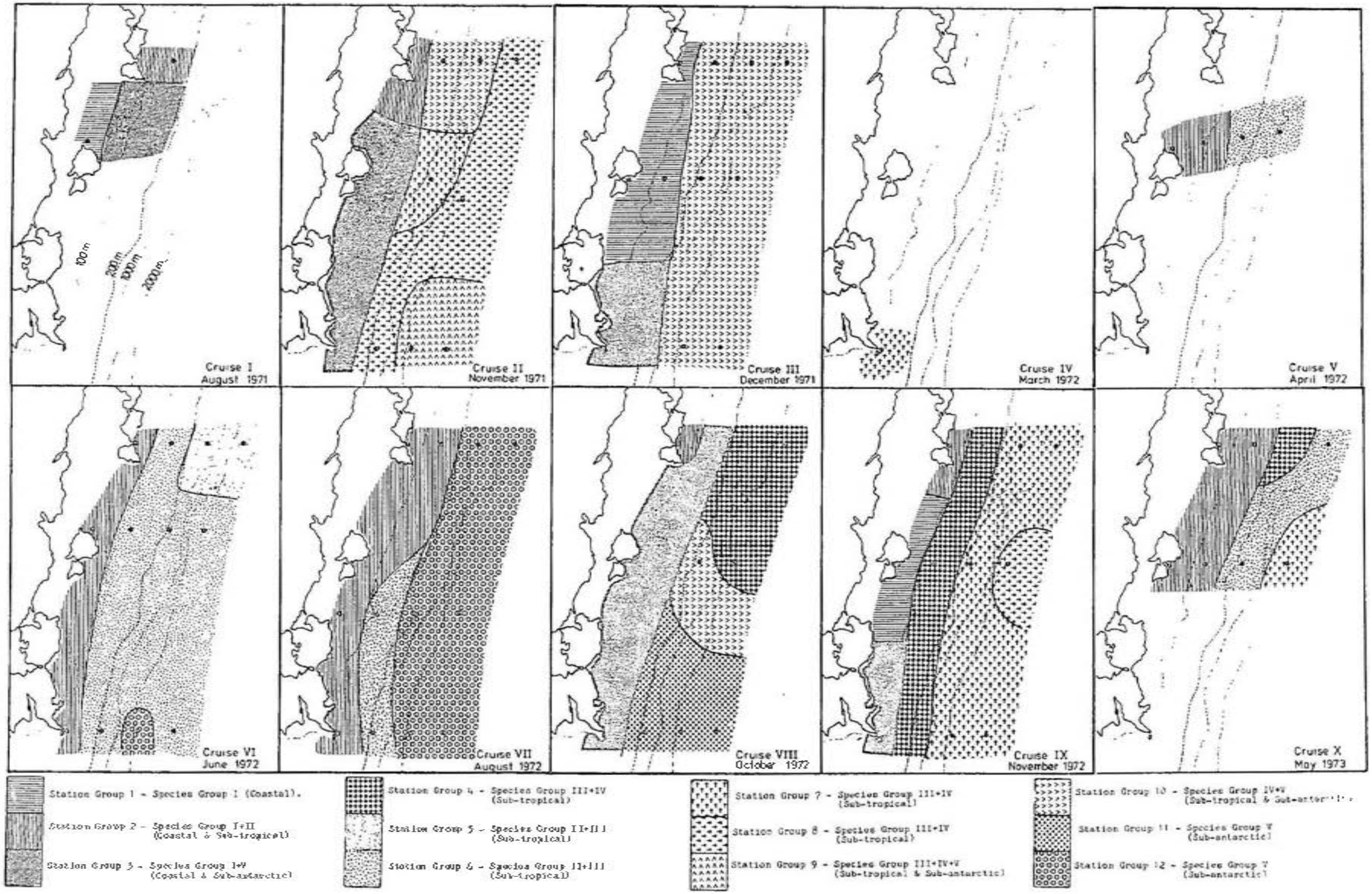

Fig. 46 Distribution of station-groups and characterizing species-groups, Cruises I – X.

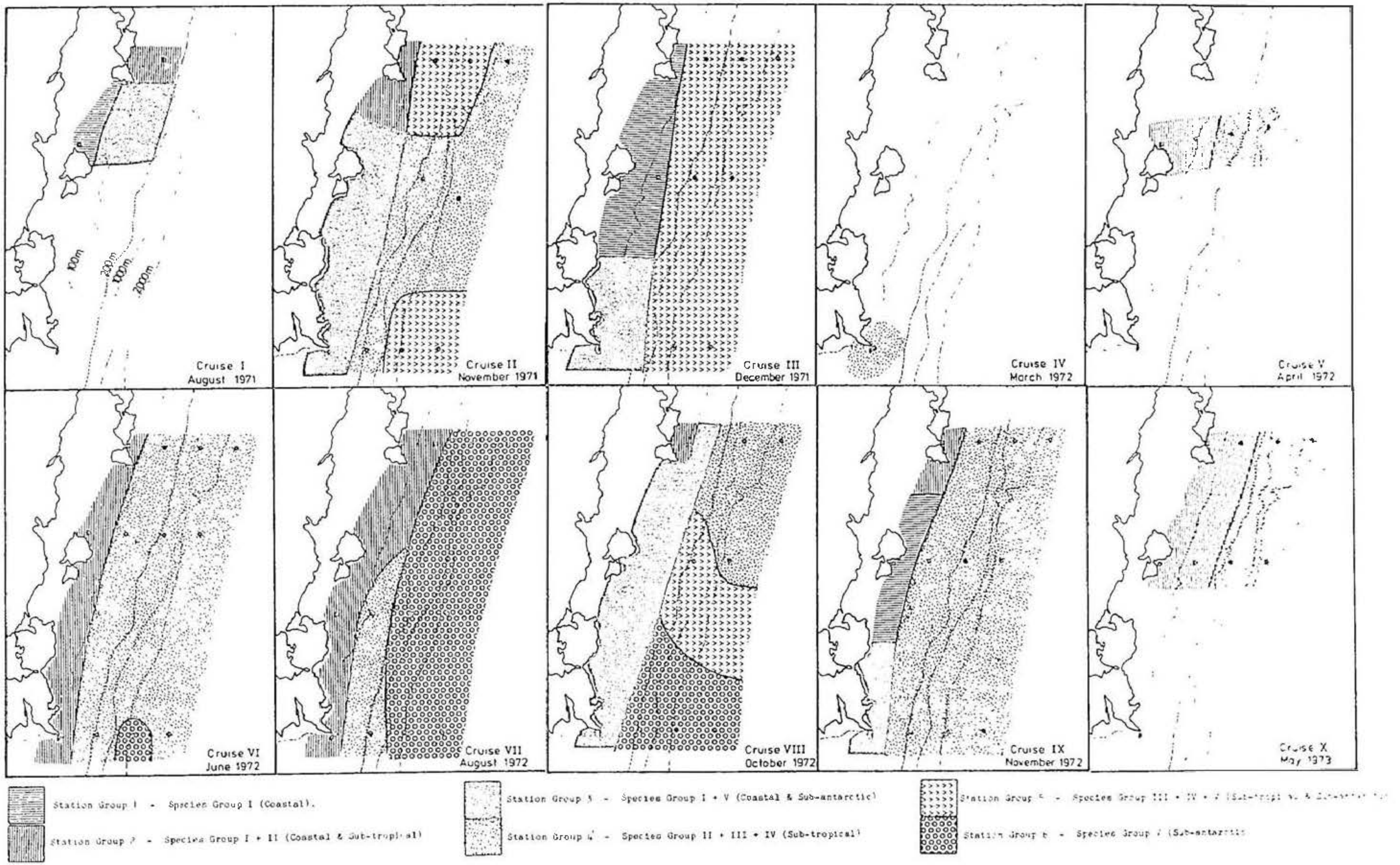

Fig. 47 Distribution of station-groups and characterizing species-groups, Cruises I – X.

	A	B	C	D
Species-Groups	Overall frequency of occurrence	Frequency in station-groups indicated	B/number of stations as % (constancy)	B/A as % (fidelity)
		Station-groups 1+2+3 - 34 stations		
Group I				
Paracalanus parvus (C)	53	34	100	64
Centropages australiensis (C)	45	31	91	69
Acartia clausi (C)	42	32	94	76
Sagitta minima (Ch)	65	32	94	49
		Station-groups 2+5+6 - 31 stations (Station-groups 2+4' - 43 stations)		
Group II				
Calanus minor (C)	48	26 (40)	84 (93)	54 (83)
Neocalanus robustior (C)	30	21 (30)	68 (70)	70 (100)
Pleuromamma abdominalis (C)	15	12 (13)	39 (30)	80 (87)
Pleuromamma gracilis (C)	31	21 (26)	68 (61)	68 (84)
Candacia bipinnata (C)	20	15 (17)	48 (40)	75 (85)
Oncaea media (C)	25	14 (20)	45 (47)	56 (80)
Sagitta lyra (Ch)	21	14 (18)	45 (42)	67 (86)
Nyctiphanes australis (E)	19	9 (11)	29 (26)	47 (58)
		Station-groups 4+5+6+7+8+9 - 35 stations (Station-groups 4'+5' - 45 stations)		
Group III				
Eucalanus crassus (C)	17	12 (13)	34 (29)	71 (77)
Leptocalanus plumulosus (C)	11	7 (7)	20 (16)	64 (64)
Euphausia recurva (E)	4	4 (4)	11 (9)	100 (100)
Nematoscelis megalops (E)	21	13 (16)	37 (36)	62 (76)
Pyrosoma atlanticum (T)	15	11 (12)	31 (27)	73 (80)
Ihlea magalhanica (T)	10	10 (10)	29 (22)	100 (100)
Salpa fusiformis (T)	6	4 (4)	11 (9)	67 (67)
Salpa maxima (T)	5	5 (5)	14 (11)	100 (100)
		Station-groups 4+7+8+9+10 - 33 stations (Station-groups 4'+5' - 47 stations)		
Group IV				
Eucalanus elongatus (C)	46	24 (28)	72 (60)	52 (61)
Rhincalanus nasutus (C)	29	21 (23)	64 (49)	72 (79)
Oncaea vanusta (C)	40	19 (19)	58 (40)	48 (48)
Pterosagitta drago (CH)	47	30 (30)	91 (64)	64 (64)
		Station-groups 3+9+10+11+12 - 34 stations (Station-groups 3+5'+6' - 34 stations)		
Group V				
Neocalanus tonsus (C)	32	20	59	63
Eucalanus longiceps (C)	20	12	35	60
Calocalanus contractus (C)	13	10	29	77
Calocalanus styliremis (C)	23	12	35	52
Clausocalanus laticeps (C)	11	9	27	82
Euchirella rostrata (C)	19	13	38	68
Euchirella rostromagna (C)	13	9	27	69
Sagitta gazellae (Ch)	30	27	79	90
Sagitta planctonis (Ch)	13	11	32	85
Eucalanus attenuatus (C)	34	17	50	50

C - Copepods
Ch - Chaetognaths
E - Euphausids
T - Pelagic Tunicates

(The values in parenthesis are derived from 5x6 Table **4**, the remaining are from 5x12, Table **3**).

TABLE 5. Composition of five species-groups, giving constancy and fidelity of individual species to the station-groups.

and very high constancy which suggests that it is not very faithful and that it still has wider associations. This is confirmed by the results from the combined (5 x 6) two-way table where its fidelity and constancy increased and becomes very high. The same feature can be observed in the remaining species, where the fidelity increased to very high, however, the constancy remaining approximately the same. Hence, the station-group is considered as mixed coastal and sub-tropical oceanic waters.

Similarly, station-group 3 is, additional to species-group I (coastal), characterized by species-group V (sub-antarctic) which includes 10 species. Among the species in the group Eucalanus attenuatus has low fidelity and low constancy; Calocalanus styliremis has high fidelity and low constancy; and the remaining species have moderately high to very high fidelity and mostly with low constancy. The notable species are Neocalanus tonsus and Sagitta gazellae, where the constancy is high and moderately high respectively as well. This suggests that they are reliable in the sense that they have a wider association and at the same time faithful to their environment. This species-group (species-group V) also characterizes station-groups 9 and 10 with other species-groups and exclusively to station-groups 11 and 12. Since station-group 3 is characterized by coastal and sub-antarctic species-groups (species-groups I and V), the area can be regarded as mixed coastal and sub-antarctic waters.

The most interesting feature in the remaining station-groups can be observed in station-group 4. The stations in the station-group 4 occupies the northern and part of middle transect oceanic area of Cruise VII and shelf waters and near shelf waters during Cruises IX and X respectively, where the temperature and salinity were sub-tropical in nature. The two-way table (Table 3) suggested that the group is characterized weakly by species-groups II and IV (sub-tropical species-groups). However, species-group I (coastal) and V (sub-antarctic) nearly reached the significant percentage. This points out that the group is also partially influenced by species-group I and V. This information is lost in the reconstructed 5 x 6 two-way table - combining similar station-groups with similar characteristic species-groups. The area occupied by the station-group 4 can be regarded as sub-tropical oceanic with some influence of coastal and sub-antarctic waters.

Species-group III consisted of 8 species, all have moderately high to very high fidelity and very low to low constancy. Three species, *Euphausia recurva*, *Ihea magalhanica* and *Salpa maxima* have 100% fidelity and very low constancy. The fidelity of species in the group becomes higher in the results obtained from the reconstructed two-way table. Species-group III also characterizes station-groups 5, 6, 7, 8 and 9.

Species-group IV has 4 species, all of which had been considered as tolerant sub-tropical species. The species, *Eucalanus elongatus*, *Rhincalanus nasutus* and *Pterosagitta drago* have high to moderately high fidelity and moderately high to very high constancy. *Oncaea vanusta* has low fidelity and moderately high constancy. An increase in fidelity and constancy is seen from the results of reconstructed table for *E. elongatus*, *R. nasutus* and *P. drago*. The fidelity and constancy remain the same in *O. venusta*. The species-group also characterizes station-groups 7, 8, 9 and 10.

Station-group 5 and 6 have similar faunistic characters (characterized by species-groups II and III). The stations in the group are distributed in the oceanic waters of Cruise V and VI; two stations on the shelf waters of Cruise VII; and an oceanic station in Cruise X (Fig. 46). Hydrologically, the area of both station-groups had the properties of sub-tropical waters. The only differences between the two station-groups is that station-group 5 is exclusively characterized by species-group II and III, whereas, station-group 6 has some, although insignificant, influences of other species-groups (Table 3). The fidelity and constancy of the species in both station-groups have been discussed under station-groups 2 and 4.

Station-groups 7 and 8 are characterized by the same species-group - groups III and IV. Some oceanic stations during Cruise II; all oceanic waters during Cruise IX; and a station each during Cruises IV and X are the areas occupied by station-groups 7 and 8. The waters occupied by the station-groups differ slightly - station-group 7 has slightly more influence (insignificant) of species-group I and species-group II than that of station-group 8.

Station-group 9 consisted of only two stations and is situated in the oceanic waters of Cruise II. The group is strongly characterized by species-group III and also by species-group IV and species-group V (sub-antarctic). Since only the temperature values (12.8°C) were available the nature of the environment could not be fully assessed. However, as the station-group is characterized by sub-tropical and sub-antarctic species-groups, the area can be regarded as mixed waters of sub-tropical and sub-antarctic.

Station-group 10 occupies the area of two stations of Cruise II, oceanic waters of Cruise III and an area of a station during Cruise VIII. The group is characterized by species-group IV (sub-tropical) and species-group V (sub-antarctic). From the available temperature and salinity data, the waters in the area can be considered, like station-group 9, mixed oceanic sub-tropical and sub-antarctic.

Station-group 11 and 12 have similar faunistic characters as well as hydrological conditions. Both station-groups are very strongly characterized by species-group V (sub-antarctic). The stations in the groups are situated in an area of a station at the southern transect during Cruise VI; oceanic waters of Cruise VII; and oceanic waters of the southern transect during Cruise VIII. The only differences between the two groups is that station-group 11 has some influences of species-group I and IV (insignificantly), whereas a slight insignificant influence of species-group II was seen in the station-group 12. The area of both station-groups can be regarded as sub-antarctic waters.

Generally, an increase in fidelity and decrease in constancy resulting from the reconstructed two-way table, additionally supports the grouping the station-groups based on related species-groups. In the process, as discussed, some information was lost, but a clear general pattern of station-groups can be obtained (Fig. 47).

SPECIES-GROUPS ABUNDANCE

The analysis in grouping of species and stations was entirely based on the presence or absence of species (qualitative data) and the wide range of abundance of various species was not taken into consideration. It is assumed that species are most abundant in their natural environment and least abundant in those areas within their range that are least suitable, than the relative abundance of a group as a whole, can be used to determine the most favourable and least favourable habitat of a species-group. For the purpose, percentages of species-groups for each station were calculated (Fig. 48). In calculation of percentage, the combined number of those of all species present at any station was considered as 100 percent. The diagram (Fig. 48) established by quantative data was found to agree with the general grouping from the analysis which was based on qualitative data.

As expected in normal cases a shift from coastal to oceanic species as one move away from the coast can be clearly seen. In the oceanic waters, a good example of the changes of oceanic water masses - sub-tropical and sub-antarctic - can be clearly observed during Cruises VI and VII. During Cruise VI the water mass was sub-tropical. By Cruise VII the water mass was totally replaced by sub-antarctic waters. This change was supported by the quality and quantity of the species-groups involved. A detailed account will be given later. It proves that species-groups and station-groups determined by the analysis using qualitative data agrees very well with natural associations of species and stations.

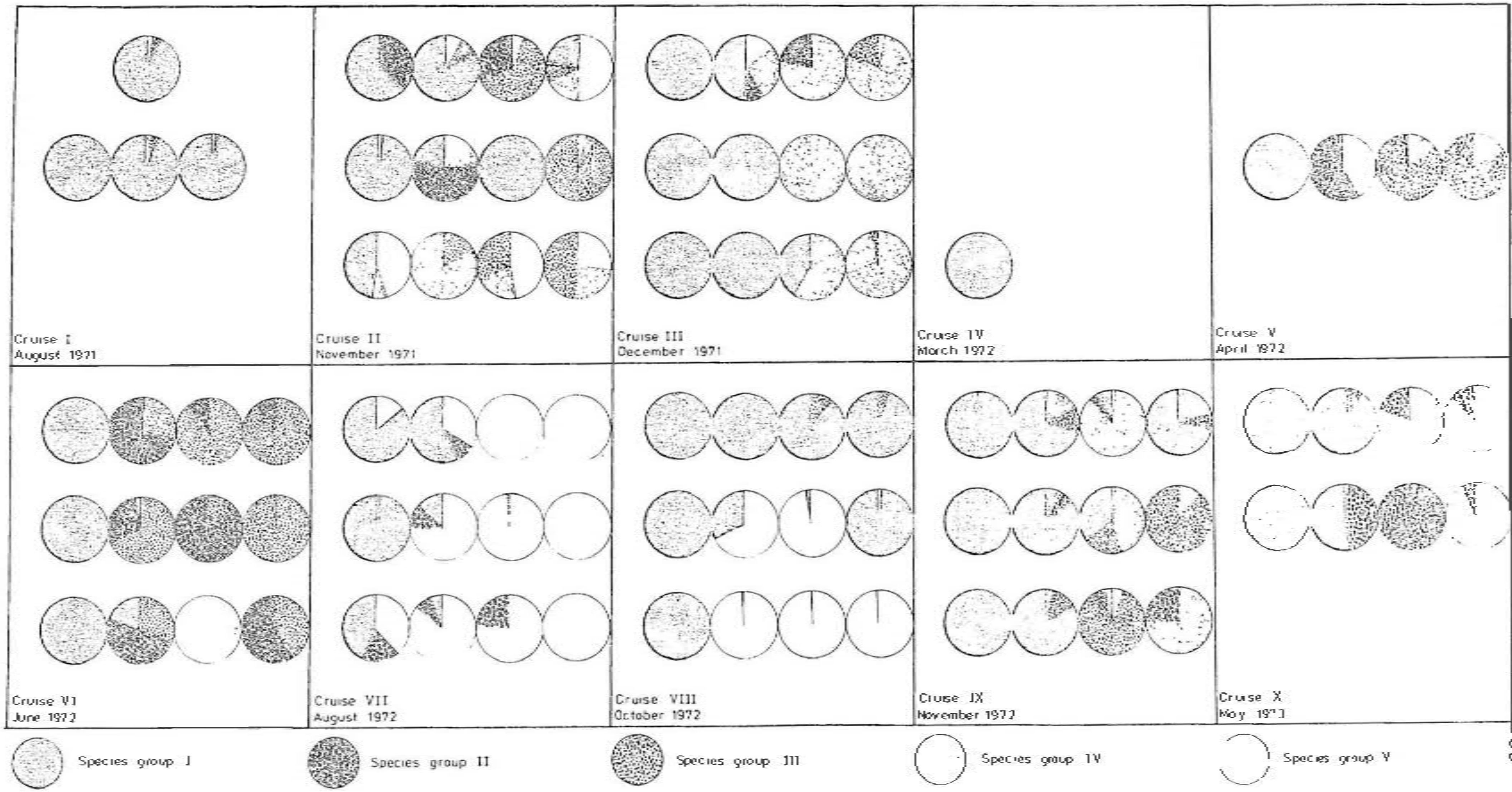

Fig. 48 Percentages of indicator species-groups – coastal (species-group I), oceanic Sub-tropical (species-groups II, III & IV) and oceanic Sub-antarctic (species-group V), Cruises I – X.

DISTRIBUTION OF WATER MASSES IN THE EAST COAST OF TASMANIA

As has been discussed, there are three types of water masses in the east coast of Tasmania - namely, Coastal, Oceanic sub-tropical and Oceanic sub-antarctic (Fig. 47). The species-groups characterizing these water masses have also been obtained from the analysis of species-groups/station-groups coincidence. The following is a general distributional pattern of water masses occurring off the east coast of Tasmania, based on the results obtained.

The nature of the water mass in the oceanic area during Cruise I was not known. However, in the coastal area, the near-shore coastal station was pure coastal in nature. The northern coastal shelf station was found to be coastal mixed with sub-tropical waters, whereas the southern stations were coastal mixed with sub-antarctic waters.

During Cruise II, apart from the northern transect near-shore coastal station which was of mixed coastal and sub-tropical waters, the remaining coastal area had a high influence of sub-antarctic waters. In the oceanic area in general the water mass was of mixed sub-tropical and sub-antarctic. A complex patchiness, evident from both quality and quantity of zooplankton species-groups found, was seen during this cruise.

By Cruise III, the influence of sub-tropical ceased in the northern and middle transects coastal area and the area can be regarded as pure coastal in nature. Sub-antarctic influenced coastal waters in the area was by this time pushed to the southern transect coastal area. In the oceanic area the water mass encountered was mixed sub-tropical and sub-antarctic.

During Cruise IV, although the sole station was at a coastal region, it was grouped together with sub-tropical oceanic stations with slight coastal influence. Possibly, the water off-shore in deeper areas could be sub-tropical in nature.

This assumption was confirmed in Cruse V where the oceanic area was pure sub-tropical. In the coastal area mixed water of coastal and sub-tropical was found.

The condition of Cruise V, in both coastal and oceanic prevailed till Cruise VI, except from one oceanic station in the southern transect where the influence of sub-antarctic was encountered.

In Cruise VII, the sub-tropical oceanic water mass which was found in Cruise VI was pushed into the coastal shelf region. The coastal area was still mixed coastal and sub-tropical waters. This was probably due to the strong intrusion of a sub-antarctic water mass from the south into the area, which dominated the oceanic area. It showed that when a water mass receded, its elements could be left behind in the coastal area.

By Cruise VII, the coastal water with sub-tropical influence had receded to the north as it was pushed by mixed coastal and sub-antarctic waters from the south. The most interesting feature was observed during this cruise in the oceanic area. The northern area, sub-tropical with minor coastal and sub-antarctic influenced waters, was confronting with the southern area, sub-antarctic with minor sub-tropical waters (minor influence means that the characterizing species-group for the station-group was just below the significant percentage of 20%. One station, characterized by both sub-tropical and sub-antarctic species-groups, was in between the two confronting water masses. This was confirmed by the hydrological conditions as well, as such, there was a strong indication of the sub-tropical convergence being between the northern and southern transect region of the study area during the cruise.

During Cruise IX the sub-tropical influenced coastal water at a near-shore coastal northern station still prevailed. The coastal waters with sub-antarctic influence had retreated to the southern transect area which left pure coastal water in the middle of the coastal area. In the oceanic area the water mass was totally replaced by sub-tropical waters.

These conditions were very much the same during Cruise X as in Cruise IX, except that the coastal area had only sub-tropical water influence.

GENERAL CONSIDERATION AND DISCUSSION

There is some contradiction to the position of sub-tropical convergence and the properties, mainly salinity of sub-antarctic waters in the Tasman Sea and vicinity east of Tasmania. Deacon (1937) who derived the position of the convergence chiefly by temperature and salinity distribution, found the convergence at latitude 45° to 47°S where the temperature increased from 11° to 13.5°C and the salinity from 34.7 to 35.00‰ . Similarly, according to Rochford (1957), sub-antarctic waters in the southwest Tasman Sea, were found at about longitude 155°E and latitude 43°S and was further south of Tasmania (Figs. 50, 51). Rochford identified the sub-antarctic water as having the chlorinity of between 19.15‰ and 19.30‰ (salinity 34.6 - 34.9‰) and the temperature between 10 and 14°C.

Wyrtki (1960) on the other hand, derived the position of the convergence from the analysis of current observations. He found that the convergence is in all months further north than that derived by Deacon and that it starts always from the east coast of Tasmania, where it is initially formed (Fig. 49). He assumed that the sub-antarctic water does not have the tendency to sink on its way to the north as much as is shown by the sub-tropical water on its way to the south. He stated that this assumption is in agreement with the more northerly position of the convergence which is at a slightly higher temperature and salinity as shown by Deacon in the region. This position was confirmed later (Wyrtki, 1962) in the study based on sub-surface waters in the region. He found that the northern limit of the sub-antarctic surface water coincides approximately with 35.40‰ isohaline during summer time.

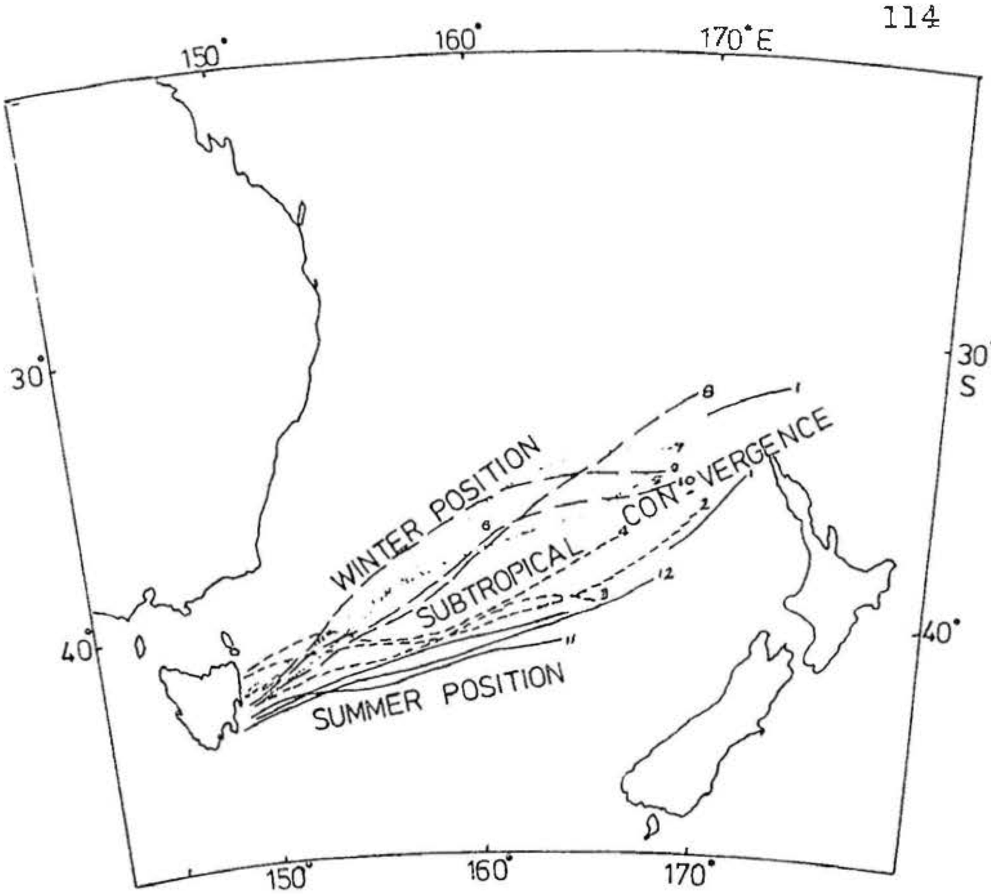

Fig.49 Position of the Subtropical Convergence in different months. Months are indicated by numbers. (Wyrtki, 1960. Fig. 15)

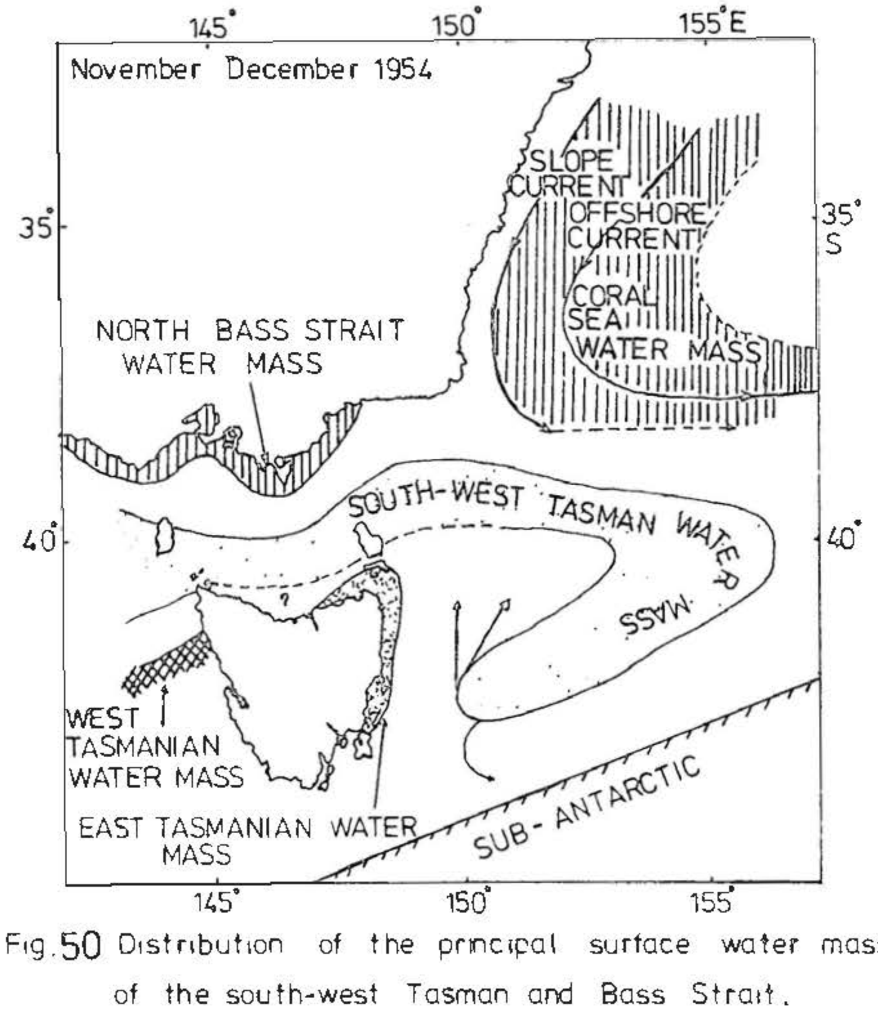

Fig.50 Distribution of the principal surface water masses of the south-west Tasman and Bass Strait. (Rochford, 1957 Fig.18)

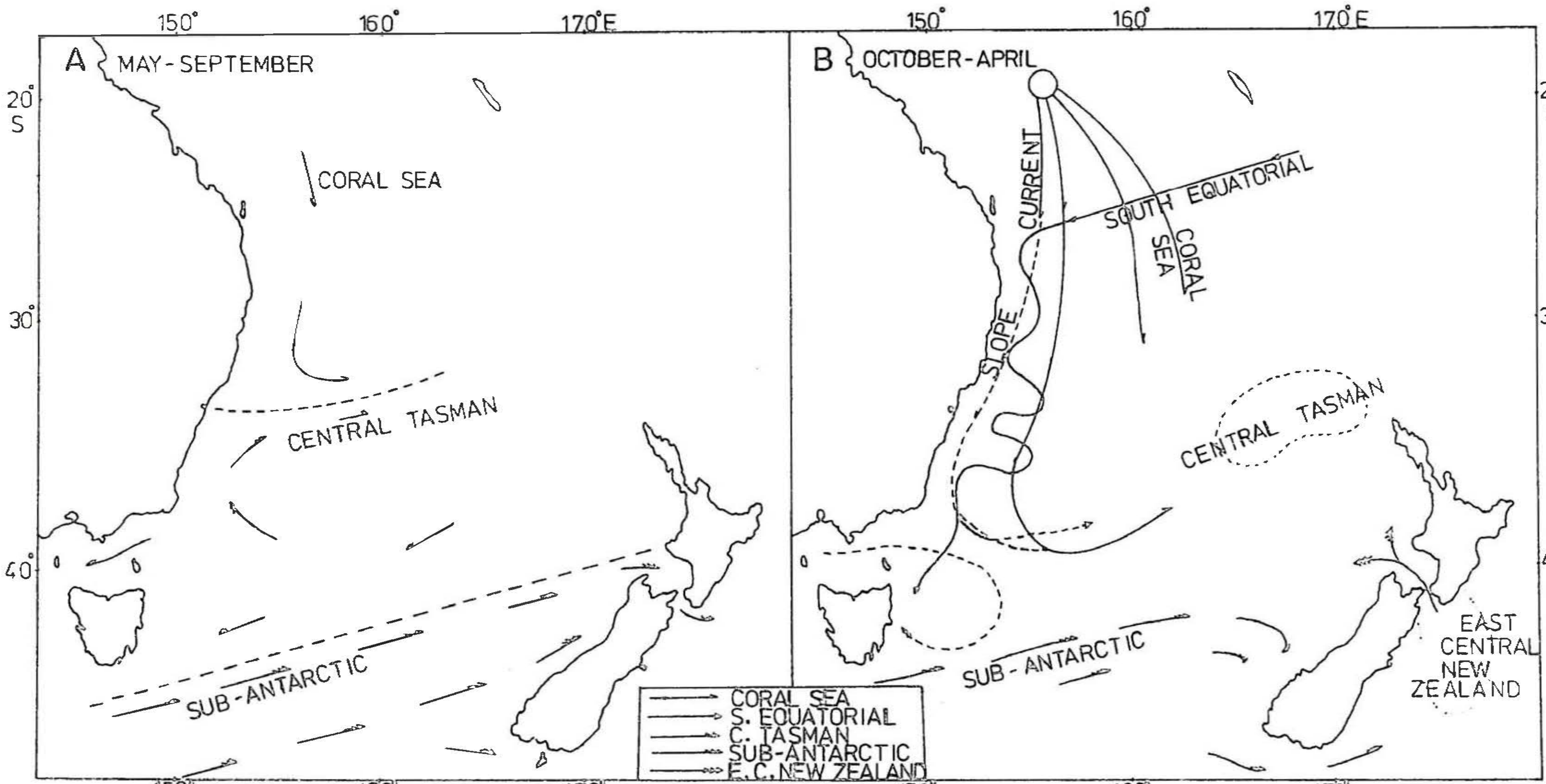

Fig.51-Probable paths of movement of the surface water masses of the Tasman Sea. (Rochford, 1957. Fig 25.)

/e The appar~~a~~nt contradiction was discussed by Stanton (1969). Stanton studied the convergence and conclusively stated, "It can thus be speculated that Wyrtki's 1960 convergence in the surface current sector in the vicinity of Tasmania was indeed part of the sub-tropical convergence while the convergence in surface current sector at the northern end should be identified with the mid-Tasman convergence.".

It is clear now that the hydrological conditions east of Tasmania and most probably in the south-west Tasman Sea are uncertain in respect to the position of the sub-tropical convergence and the upper limit of surface salinity of sub-antarctic waters. In a situation like this, as pointed out by Fraser (1952), the plankton indicator method of approach would give valuable aid.

The five species-groups resulting from the analysis have been identified as coastal (species-group I), sub-tropical (species-group II, III and IV) and sub-antarctic species-groups (species-group V). Seven species of the nine species in the species-group V, namely, Neocalanus tonsus, Eucalanus longiceps, Clausocalanus laticeps, Euchirella rostromagna and Sagitta gazellae are known endemic species of sub-antarctic, antarctic waters whereas Eucalanus rostrata and and Sagitta planctonis are known to be common in sub-antarctic waters. Finding these species in large numbers and high percentages of this group (Fig. 48) suggests the presence of sub-antarctic waters in the area.

A general distribution of water masses in the study area are based on biological evidence (both qualitative and quantatative) have been given. There is clear evidence that the water mass found in the oceanic area during Cruis VII and the water mass in the southern transect area during Cruise VIII was pure sub-antarctic, which was supported by cold, low salinity waters ($<12.5^{\circ}$C and $< 35.16‰$) where the values are within the values given by Wyrtki (1962). During Cruise VIII, as had been discussed, the confrontation of sub-tropical and sub-antarctic water masses was encountered. The results based on zooplankton groups was supported by the hydrological feature where the temperature increased from 12.5 to 14.5°C and the salinity increased from 35.11 to 35.84‰ . This suggests that the sub-tropical convergence was indeed between the northern and southern transect in the study area during the cruise.

The mixed water mass (unfortunately salinity values were not available) found during Cruise II and III was probably part of the region of sub-tropical convergence. Deacon and Defant (1913) (1938) found the sub-tropical convergence to be ill defined. It is more correct to define the convergence as a region of convergence instead of a line (Defant).

It is now evident that sub-antarctic waters do extend into the east coast of Tasmania for about five months of the year (sub-antarctic influence from August, 1971 to December, 1971: June, 1972 to October, 1972). During the remaining months the area was sub-tropical in nature. This supported Wyrtki's (1960, 1962) findings on the position of sub-tropical convergence which oscillate north and south in accordance with seasons off the east coast of Tasmania.

The circulation and movement of water masses in the Tasman and Coral Seas was studied by Rochford (1957, 1958). A general conclusion of the seasonal circulation was given in his 1958 paper. The distribution of water masses found in the east coast of Tasmania agrees with Rochford's pattern of circulation, except that the sub-antarctic water intrudes further north, at least, off the east coast of Tasmania, than as given by Rochford.

Generally, according to Rochford (1957) the east coast of Tasmania is influenced strongly by the eastward flowing water mass from the Tasman Sea from May to September (Fig. 51). The direction of the water mass changes from October to April and flows westward. The water mass from the eastern approaches of Bass Strait flows back to the east in latitude 38°S and curves south in a clockwise gyral off eastern Tasmania in about 42°S (Fig. 50 and 51). The water mass found in the northern transect with coastal influences during Cruise VIII (October) was possibly the water mass from the eastern approaches of Bass Strait. This coastal influenced sub-tropical water mass persisted in Cruise IX (November, 1972). The water masses devoid of coastal influences found during Cruises V, VI and VII (April, June and August) were probably due to the strong influence of eastward flowing current from the Tasman Sea, mentioned by Rochford, from May to September.

The evidence showed that the grouping of species and stations which was entirely based on the selected species, correspond very well to the natural environmental conditions. However, to have a better understanding of the situation one must not exclude, in considering the condition of the area, the species which had been rejected from the analysis, mainly the common and ubiquitous species. The species are local oceanic species. They are namely, Mecynocera clausi , Calocalanus tenuis, Clausocalanus ingens, Thysanoessa gregaria and Sagitta serratodentata tasmanica. M. clausi has a world-wide distributional record, including sub-antarctic waters. The distribution of C. tenuis is not well known and the present record is the first record in Australian waters, although it had been recorded in waters off central east coast of New Zealand. The identity and distribution of C. ingens was not known until recently (Frost and Fleminger, 1968). According to them it is distributed in the southwest Pacific Ocean, approximately 30°00'S and 55°00'S. T. gregaria and S. s. tasmanica have similar distributional range - from waters off New South Wales to as far south as Maquarie Island. Among these species, T. gregaria and S. s. tasmanica had been considered as indicators of southern sub-antarctic and northern sub-antarctic waters respectively (Bary, 1959). However, in the present area there was no indication of preference to any particular water mass by these two species. The distribution of the local species is generally southern sub-tropical and sub-antarctic region which explains why they could not be used as an indicator of either sub-tropical or sub-antarctic waters.

The occurrence and distribution of zooplankton species in the present study area is very much similar to that of the species found off the central east coast of New Zealand. However, the salinity values of sub-antarctic waters indicated by sub-antarctic species in the present study, was higher than the salinity values of sub-antarctic waters off the central east coast of New Zealand.

Fager and McGowan (1963) working in the north Pacific Ocean, found that for certain species groups (in their case sub-arctic species-groups), the history of water may be the most important property and that, from the standpoint of the biologists, the hydrographic properties usually measured on oceanographic expeditions, may not be the right ones. The evidence of eastern Tasmania suggests that similar historical evidence is of equal importance here.

It is evident that in an area where water masses confront and mixing occurs, the method and the procedure used gives valuable information. Generally, the results obtained by the analysis correspond very well with the natural conditions - both hydrological and biological conditions. In the grouping of species, a few species were grouped with the species which are not in natural association. This is probably due to the number of stations operated, the catchability of the net and in some cases, the habitat of the species. Had there been more stations operating at regular intervals, such misgrouping may have been resolved. Stephenson (1973) points out that in ecology, the absence of a species from a station (site) may mean only it is relatively rare, while the absence of a character in taxonomy is usually meaningful. However, the misgroupings can be clearly detected from their constancy and fidelity to the group.

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SECTION III

ZOOPLANKTON AND HYDROLOGY OF INSHORE COASTAL WATERS OF SOUTH-EASTERN TASMANIA

INTRODUCTION

Wood (1954) found some evidence that the Sub-tropical Convergence may have moved as far as Storm Bay as shown by the presence of Sub-antarctic planktonic dinoflagellates. Later, having encountered a number of species of ~~D~~inoflagellates which /d are of oceanic origin, he regarded the Bay as having an oceanic character and that southerly winds tend to preserve this character (Wood, 1964).

However, as zooplankton species of oceanic origin were not reported by Ong (1967) during his study on the surface water plankton at the mouth of the Derwent River estuary which opens into Storm Bay, appears to suggest that there was no oceanic influence in the area.

Since the marine zone extends as far as Cornelian Bay in the Derwent River estuary (Guiler, 1955) and if Storm Bay is of oceanic character, there is a possibility of oceanic water influence at the mouth of the Derwent River estuary, the area studied by Ong.

Although the presence of Sub-antarctic waters off the east coast of Tasmania supports Wood's 1954 finding, the assumption that Storm Bay has an oceanic character (Wood, 1964) is not certain due to the fact that an inshore station off Tasman Island was usually coastal in nature but with a strong oceanic influence (see Section II).

These suggest that the area, an important part of marine ecosystem as well as being the region confronting with industrial waste discharge and domestic sewage, is in need of further thorough investigation.

Three stations were selected to cover the D'Entrecasteaux Channel, mouth of the Derwent River and the Storm Bay areas where surface, midwater and bottom zooplankton samples were collected monthly for a period of twelve months during day as well as night time. Data for temperature and salinity were also obtained from the Stations. It is hoped that the results of the present work will lead to a better understanding of the area.

MATERIALS AND METHODS

Field Procedure

Zooplankton

Zooplankton samples were collected at the inshore coastal waters of southeastern Tasmania (Fig. 1) on the dates and time as shown in Table 1.

A simple net with a mouth area of $0.25m^2$ and $200\mu m$ mesh size, having a throttle with Nansen closing system (Fraser, 1966) was used. A flow metre of the type Tsurumi-Seiki Kosakusho was fitted from three points on the ring and centred 14.25cm from the rim which weighed 6.5 kilograms. Later, some modifications were made on the net and now known as WP-2 net(UNESCO, 1968). The net was designed with a hopeful approach towards standardization, aimed at giving an assessment of the biomass of the zooplankton from $200\mu m$ upwards to about 10mm (Fraser, 1966). Since the sampling depth in the present study was shallow ($\geqslant$ 20m), horizontal tows were made in the zooplankton collections without the lead weight recommended for vertical tows. The flow metre was calibrated after every third field trip.

The Zoology Department Research vessel, "Neotrigonia" was used for the field collection trips. Surface horizontal tows were

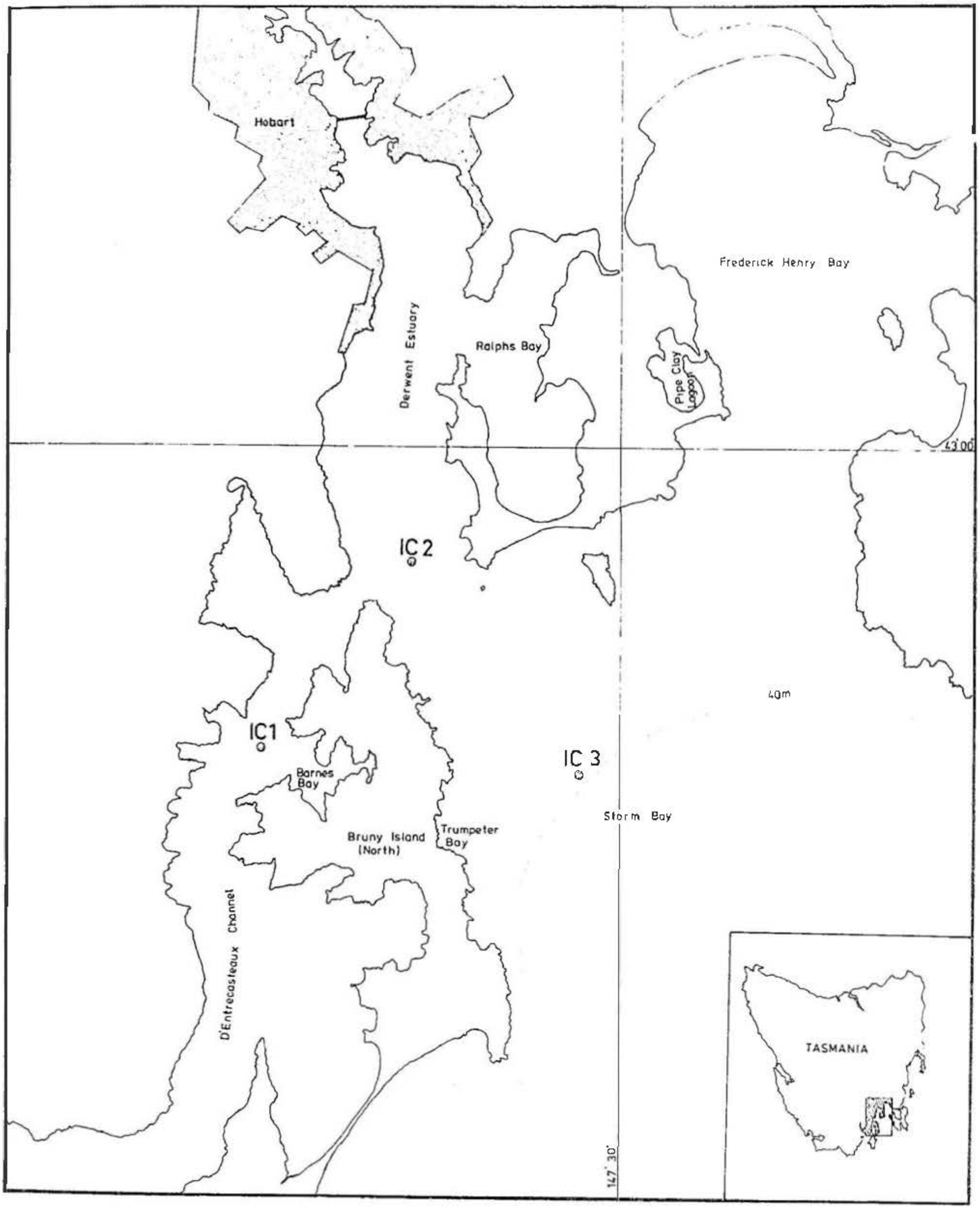


Fig. 1 - Study area showing position of the stations.

TABLE 1

Dates, time and weather conditions of the monthly sample collection at Stations IC1, IC2 and IC3.

DATE	Time (Australian Eastern Standard Time)			
	Sta. IC1	Sta. IC2	Sta. IC3	Weather Conditions
19. 8.71	1045	1315	1500	Overcast
19. 8.71	2020	1915	1800	
16. 9.71	1400	1540	1715	Fine
21. 9.71	1350	2000	2130	
19.10.71	1010	1130	1340	Overcast
19.10.71	2110	1950	1830	
26.11.71	0900	1045	1200	Fine
29.11.71	2230	2130	2025	
14.12.71	1330	1215	1030	Overcast
22.12.71	2240	2135	2010	
10. 1.72	1430	1315	1145	Heavily overcast
14. 1.72	2230	2120	2020	
21. 2.72	0930	1140	-	Overcast
-	-	-	-	
20. 3.72	1545	1650	1830	Fine
20. 3.72	2130	2015	1900	
20. 4.72	1420	1530	1635	Fine
20. 4.72	2020	1915	1810	
25. 5.72	1330	1440	1550	Overcast
25. 5.72	1950	1850	1730	
15. 6.72	1415	1525	1635	Fine
15. 6.72	2005	1850	1740	
25. 7.72	1345	1455	1615	Fine
25. 7.72	2015	1830	1730	

made with the vessel's speed approximately 1.5 to 2.0 knots. To obtain a sample at a required depth the net was lowered with the rim in the vertical position while the vessel was in motion at approximately 0.5 knots. On reaching the required depth the cable was locked and the speed of the vessel increased to 1.5 to 2.0 knots. The net was towed horizontally against tidal currents if any. The angle of the cable was maintained at approximately 35°. For mid-water samples 10 to 15 metres and for bottom samples 20 to 25 metres of cable was released, depending on the depth of sampling area. This was to sample zooplankton from the depths of between 5 - 10m and 15 - 20m respectively. The maximum time elapsed for each tow was about three minutes. A messenger was used to close the net. The net was open while it was lowered and would fish on the way to the required depth. However, the volume of water passing through the net at this stage would be low. Since the volume of water filtered was usually about 35 cubic meters and the maximum depth sampled was 20m, this accidental contamination would be negligable.

The net was washed after each sampling. The zooplankton sample was preserved in approximately 5% formalin immediately after each collection to minimize the effect of predation. Zooplankton was sampled once a month, at three depths - surface, midwater (approximately 10 meters) and bottom (approximately 20 meters) during the day and another three samples at night at each station. The night samplings were operated about half an hour after sunset. Due to weather conditions, it was not always possible to obtain the day and night samples on the same day or commence from the same stations (Table 1). A collection was missed at Station IC3 and only day time sampling was made at Stations IC1 and IC2 in February due to engine trouble in the vessel.

Hydrology

Temperature: A thermometer marked in 0.5°C was used to measure the temperature until January, 1972. From February onwards, a thermometer marked 0.1°C was used. Sub-surface water temperature was measured from the water sample brought to the surface by the Nansen Reversing bottle. Later, the temperature recorded by the above method was compared with the temperature measured by a protected reversing thermometer. The difference was found to be insignificant in waters under 20 meters depth.

Water Samples for Salinity Determination

A Nansen Reversing bottle was used to collect sub-surface water samples. The water samples were collected immediately after the plankton sampling and were stored in screw tight narrow necked unbreakable polyethylene bottles. The salinity values from the water sample stored in polyethylene screw tight bottles and normal air tight glass bottles were compared, no difference being found.

Laboratory Procedure

Zooplankton

Sub-sampling and Counting

The same method and procedure was used in sub-sampling and counting of zooplankton species as described in Section II.

For common copepod species *Paracalanus parvus*, *Acartia clausi*, *Centropages australiensis* and *Calanus australis* the numerical abundance given is of copepodite stages and adults combined. The whole range of copepodite stages of C. australiensis and C. australis were found, however, amongst P. parvus and A. clausi due to their small and the mesh size (200 m) of the net used the catch mainly consisted of copepodite stages IV to VI. Only adults were enumerated on the remaining uncommon copepod species, unless otherwise stated.

Biomass (Wet displacement volume)

The wet displacement volume of formalin preserved zooplankton samples were measured by the mercury immersion method (Yentsch & Hebard, 1957). Before measuring the volume large non-crustacean zooplankton - Salps, Coelenterates, Ctenophores, Chaetognaths and Annelid worms - were removed. The resulting values were converted to millilitres per 100 cubic metres.

Hydrology

Salinity: In the early part of the project, from August to November, 1971, for Stations IC1, IC2 and IC3, the salinity was determined by titrating 10 ml. of sea water against 27.25gm/litre of Silver Nitrate (Ag NO_3) using flouresein blue as an indicator (Harvey, 1955). The Copenhagen Standard sea water was used for calibration. From the December collection onward the Inductive Salinometer was used to determine the salinity. The apparatus was calibrated before each batch of determinations, using Copenhagen Standard sea water. The Inductive Salinometer has an accuracy of approximately 0.003 parts per milli (Brown and Hamon, 1960).

THE ENVIRONMENT

Temperature

Seasonal depth profile of temperature for all Stations is given in Figure 2. Maximum temperature was observed in February and the minimum was found in July over the period of 12 months, - August, 1971 to July, 1972. From September to February surface temperatures were usually higher than those of subsurface waters. Water columns, where the temperature decreased with depth were found from March onwards. This was most probably due to the seasonal changes in air temperature.

Salinity

Seasonal depth profile of salinity for all Stations is shown in Figure 2. A pronounced stratification of the water column with low salinity surface waters was observed from September to December at Stations IC1 and IC2 and in December at Station IC3. Similar stratification of the water column with low salinity surface waters was found again in June at Station IC1; June and July at Station IC2; and in July at Station IC3. During the remaining months the water columns were almost isohaline, however, with slightly higher salinities at subsurface waters. The high salinity at 20m. depth at Stations IC1 and IC2 in October was probably the extension of high surface salinity waters found at Station IC3 during the month. This high salinity surface water intrusion was shortlived at Stations IC1 and IC2 in November, most probably resulting from the freshwater flow from the Derwent River (see paragraph below on Derwent River runoff). Although low salinity surface water was found at Station IC3 in December, at 20m. depth high salinity water intrusion was apparent.

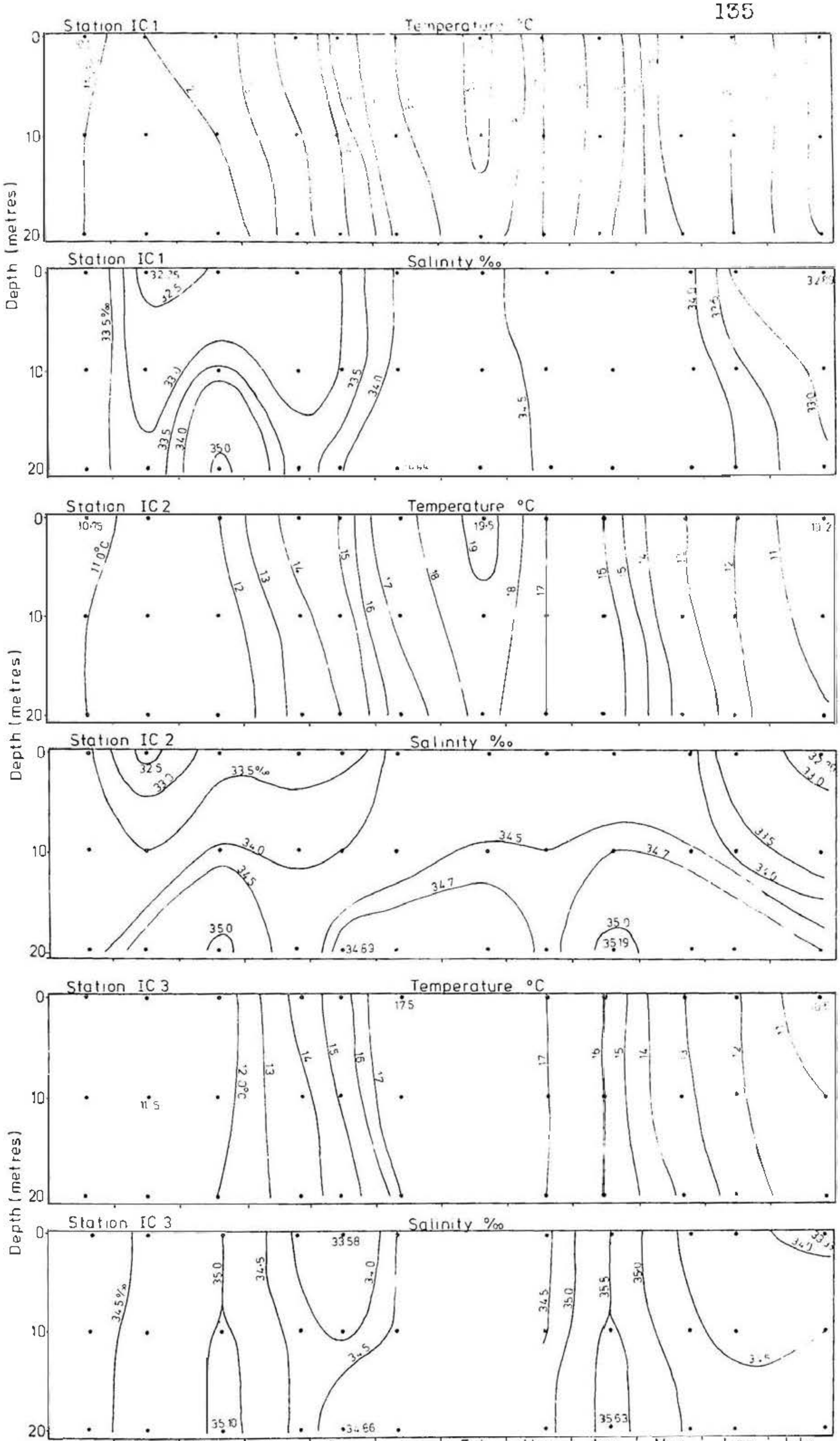


Fig. 2 Seasonal depth profile of temperature and salinity at stations IC 1, IC 2 and IC 3 (black dots indicate points from which samples were taken)

This high subsurface high salinity water intrusion can also be detected at Station IC2 and to a lesser extent at Station IC1. From then onwards until July, salinity increased gradually at Station IC3, reaching to a maximum in April, when the salinity was 35.63‰ at 20m depth and decreased salinity was observed in May and June. Similar patterns with high salinity subsurface waters were found at Stations IC1 and IC2. In July, although freshwater influence was obvious, having low surface salinity at Station IC3, a return of high salinity subsurface water can be seen.

Derwent River Runoff

The Derwent River runoff, day to day, data was made available by the Hydro-Electric Commission of Tasmania which was recorded at Macquarie Plains. The flow was measured in cubic feet per second (CUSECS). The data was presented in an average of a week (Fig. 3). The maximum flow was recorded in the last week of October, 1971, which reached 12,697 CUSECS and the minimum of 1,025 CUSECS in the first week of January, 1972. In general, the freshwater discharge was high from July, 1971 to the first week of December, 1971, however, a very high flow was recorded in the second and last week of October and again in the last week of November. From the second week of December, 1971, to the second week of July, 1972, the river discharge was found to be low. A high freshwater flow was recorded again in the third and last week of July.

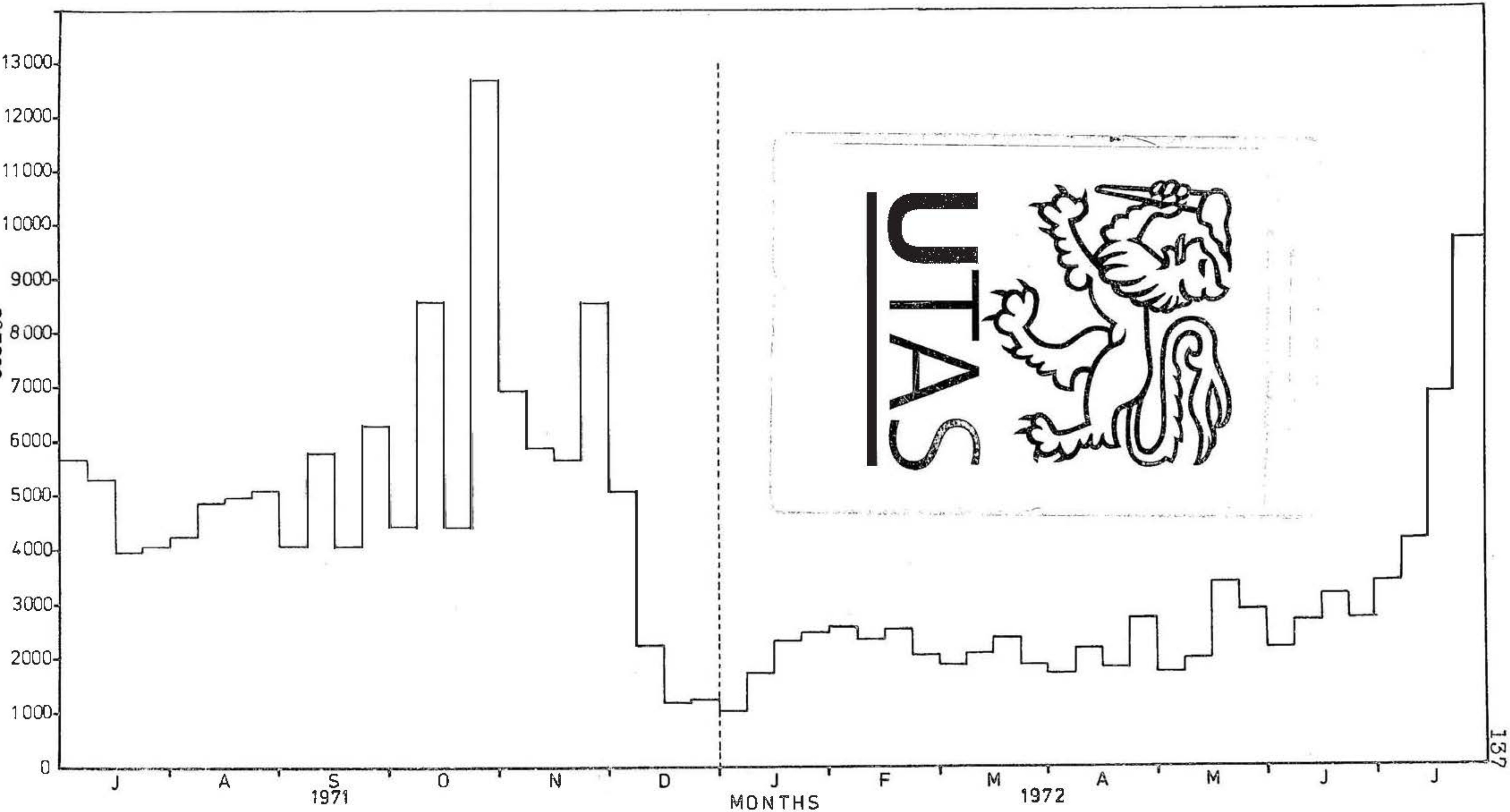


Fig. 3 Derwent River flow at Macquarie Plains.

SEASONAL DISTRIBUTION OF ZOOPLANKTON BIOMASS.

The monthly mean biomass (surface, 10m and 20m) of zooplankton without Salps, Coelentrates, Ctenophores, Chaetognaths and Annelid worms, in ml/100m^3 for the day and night plankton tows for all Stations is given in Figure 4. A maximum was observed in December at Stations IC1 and IC2 and in January at Station IC3. The maximum mean biomass was found in December during the night at Station IC1, reaching 114.76 ml/100m^3. The minimum mean biomass was in February in the daytime sample which was as low as 0.43 ml/100m^3. The December maxima at Stations IC1 and IC2 could possibly be due to the turbulence caused by the strong freshwater flow which was recorded in October and November (Fig. 3). The December maxima at Stations IC1 and IC2 were mainly composed of the coastal copepods *Paracalanus parvus*, *Acartia clausi* and Furcitia larval stages of Euphausid *Nyctiphanes australis*. However, the January maximum at Station IC3 mainly contained high numbers of Stage V copepodites of *Neocalanus tonsus*, an oceanic species. The January maximum at Station IC3 is comparable with that recorded in December off Kaikoura, New Zealand central East coast, by Bradford (1972) which was also composed of high numbers of Stage V *Neocalanus tonsus* copepodites.

The mean biomass for all Stations of both day and night samples for the whole study period was 9.49 ml/100m^3 (Table 2). The mean biomass values were also calculated for the three Stations, the highest being at Station IC1 and the lowest at Station IC3. Apart from a few months at Stations IC1 and IC3, the biomass was higher during the night samples (Fig. 4).

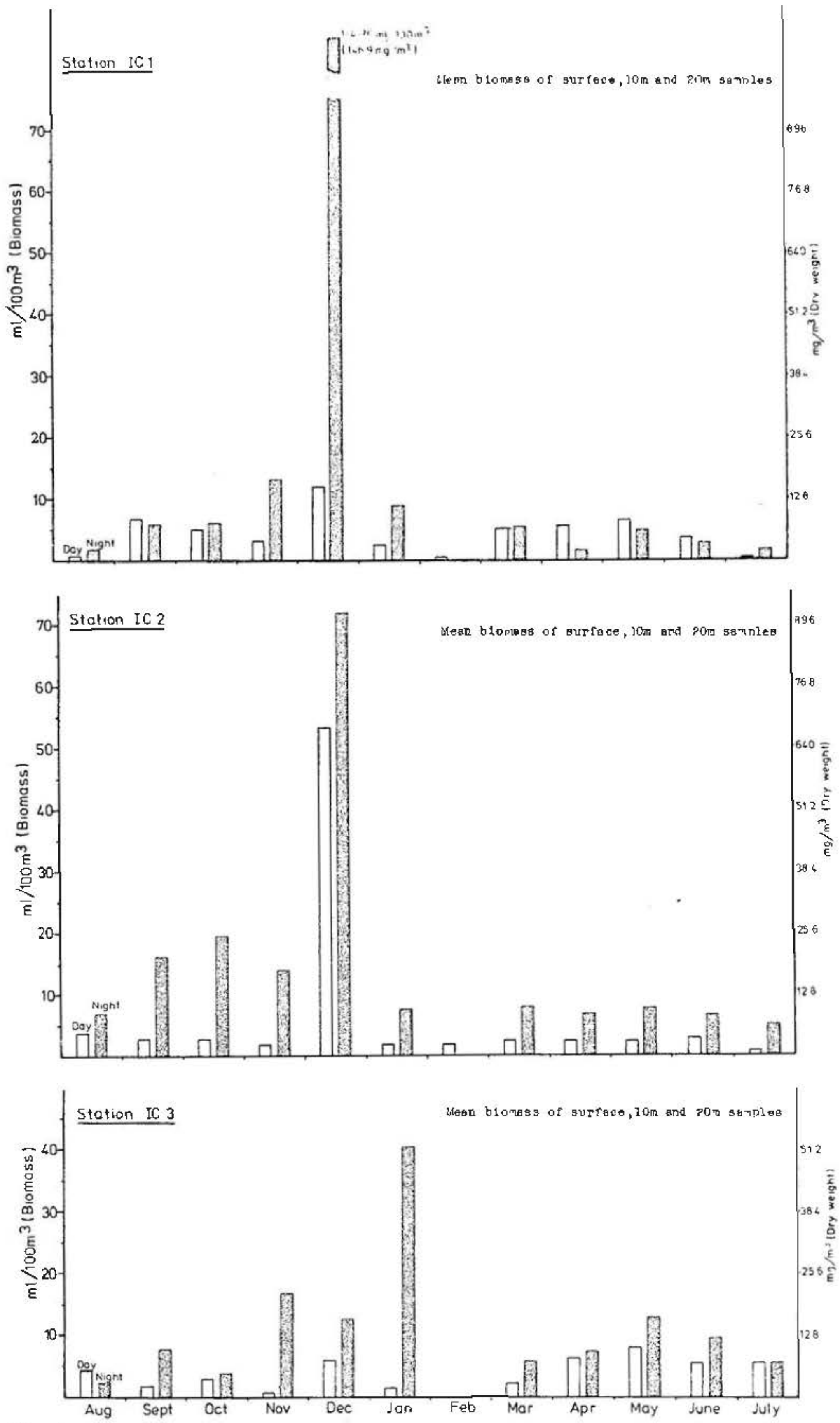


Fig. 4 Zooplankton biomass at stations IC1, IC2 and IC3.

The annual mean biomass for the Stations of day values were between 0.29 and 0.42 times the night values (Table 2). Tranter (1969) during a study of the zooplankton biomass in the Indian Ocean, estimated that day values were 0.59 times the corresponding night values. Bradford (1970) found that the surface day values 250m off Kaikoura, were between 0.38 and 0.48 times the night values, but at 250-500m it was 1.43.

Tranter (1960) gave a factor for converting volume to dryweight of zooplankton biomass. The conversion factor for a zooplankton biomass, predominantly copepods, given was based on the method he used in removing interstitial water to determine the volume by thorough washing in alcohol which quickly evaporates on exposure to air. The method used here was essentially the same as Tranter's 1960 method. Since the biomass in the present study consisted of predominantly crustaceans, mainly copepods, the factor 128 mg/ml could be used to convert ml/100m^3 to mg/m^3 for comparison with other works. However, Herbert (1962) used the same method as in the present study to determine the zooplankton biomass and found that the conversion factor is approximately 200 mg/ml for copepods. One must be very critical in using any conversion factor as such, with absolute certainty as the factor would vary depending on the type and structure of zooplankton groups.

The mean dry weight of zooplankton biomass including Salps at Port Hacking 100m station during 1959-60 was 23mg/m^3 (Tranter, 1962). Bradford (1972) found that yearly average biomass at the Station off Kaikoura, New Zealand, was approximately half that of Port Hacking. If Tranter's 1960 conversion factor is used, the present study area can be considered as rich as off Kaikoura

TABLE 2.

ZOOPLANKTON BIOMASS

The values in parenthesis are converted dryweight values using Tranter's 1961 conversion factor - 128mg/ml. The biomass does not include Salps, Coelenterates, Ctenophores, Annelid worms and Chaetognaths.

Biomass (ml/100m^3) of Storm Bay plankton at three Stations.

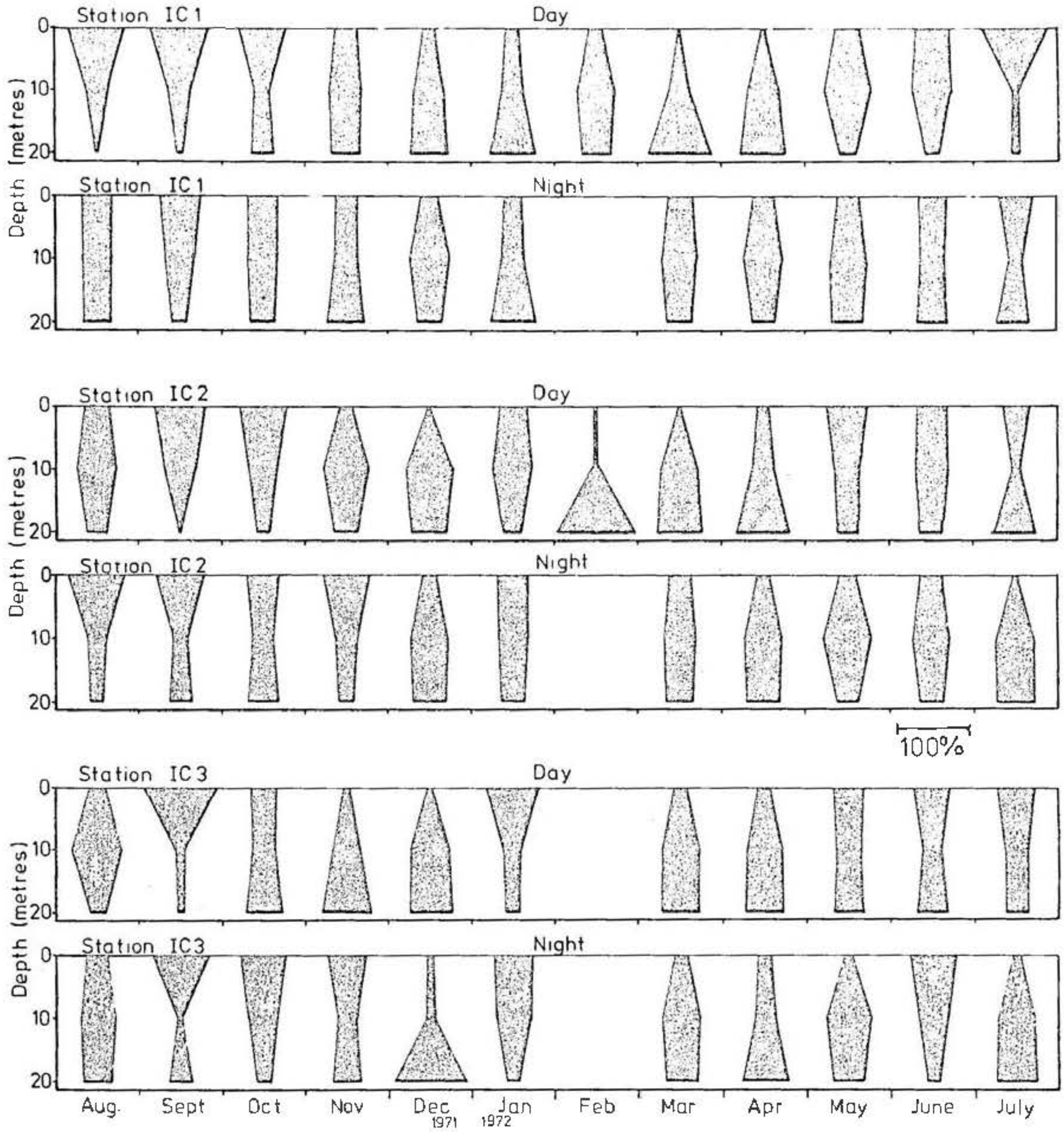
STATION	Mean of Surface, 10m & 20m from August, 1971-July, 1972.		Mean for day and night samples	Day/ Night
	Day	Night		
IC1	4.34	15.15	9.75	0.29
IC2	6.50	15.42	10.96	0.42
IC3	4.05	11.45	7.75	0.35
Mean for all Stations	4.96 (6.35mg/m^3)	14.01 (17.93mg/m^3)	9.49 (12.15mg/m^3) Total mean	

(see Table 2) since the catchability of the net used here is lower than the net used by both Tranter (1962) and Bradford (1972) who used a Clarke-Bumpus sampler with the towing speed of 2 - 4 knots compared with $0.25m^2$ mouth area standard net with towing speed of 1.5 - 2 knots in the present study.

SEASONAL VERTICAL DISTRIBUTION OF ZOOPLANKTON BIOMASS

Figure 5 shows the diurnal vertical distribution of the zooplankton biomass at monthly intervals from August, 1971 to July, 1972 for the three Stations. The dates, sampling times and weather conditions are given in Table 1. The sampling hours at each Station, due to weather conditions, were not consistent from month to month. The range of sampling times for the Stations is shown in Figure 6. The day sampling time to assess seasonal vertical distribution of biomass for Station IC1 can be, however, considered as reasonably consistent as the hours ranged between 0805 and 1045 in the morning and 1330 and 1545 in the afternoon. At the remaining Stations, although sampling hours were not consistent from month to month, the samplings were done only during daylight hours (Fig. 6). The sampling hours for night collections fall between sunset and to about 1½ hours before midnight for all Stations.

The monthly vertical distribution of the zooplankton biomass for the three Stations showed a similar pattern during daylight hours. Apart from the January distribugion at Stations IC2 and IC3, where the biomass decreased with depth, the biomass increased with depth from late Spring (August) to mid-Autumn (April) at all three Stations. At Station IC1 where the sampling hours were consistent, the biomass decreased with depth in August, September and July and an almost even distribution was found in October, May and July. This pattern generally appeared



(Biomass at each depth is expressed as a percentage of total biomass)

Fig. 5 Distribution of zooplankton biomass with depth at stations IC1 IC2 and IC3.

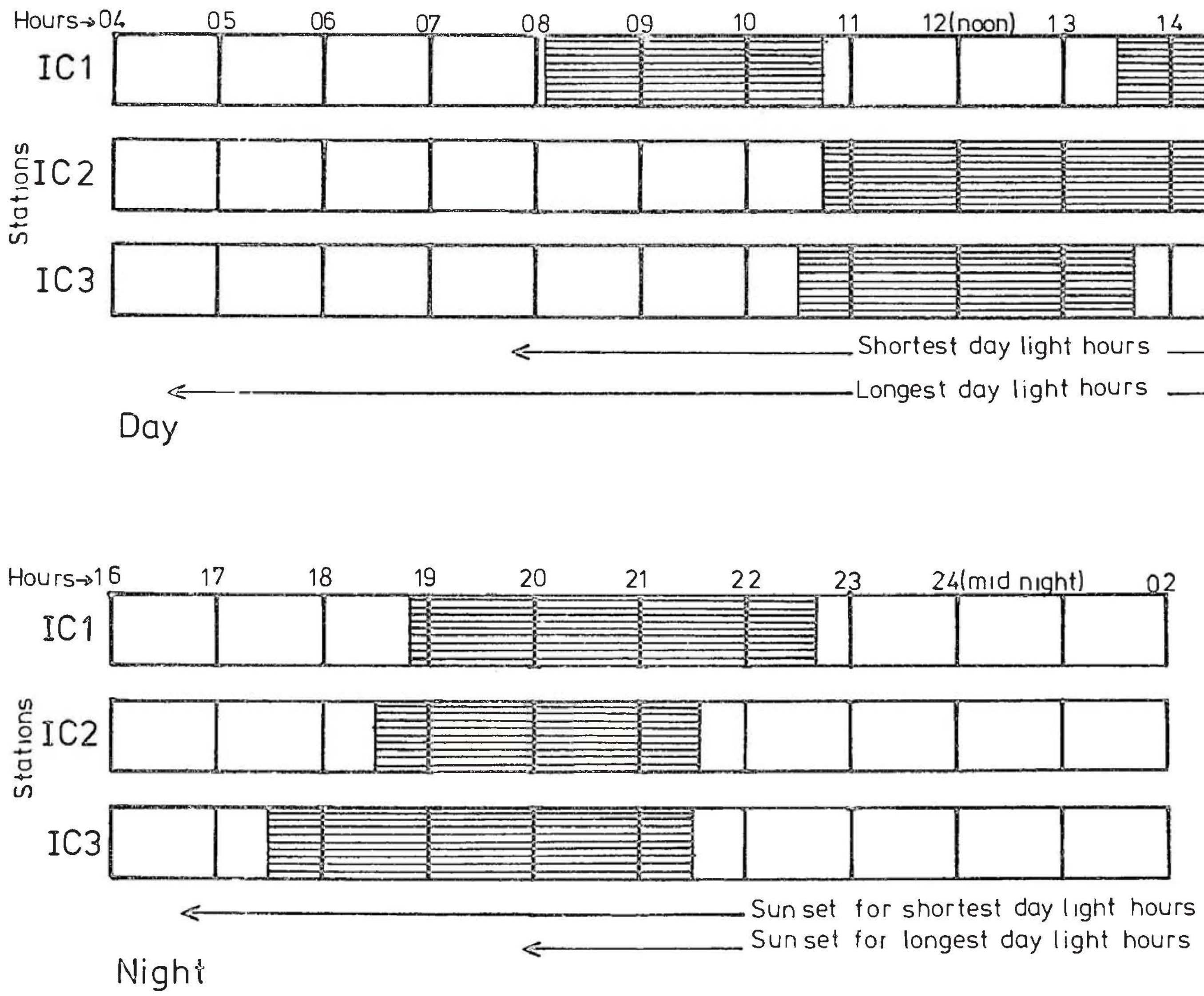


Fig. 6 Range of sampling hours (shaded area) during day and night from August 1971 to July 1972 at stations IC1 IC2 & IC3

Stations IC1 and IC2 in January could be accounted for by the very heavily overcast weather conditions. Normal overcast weather did not appear to have any effect on the seasonal vertical distribution of zooplankton biomass. During the night the distribution partially followed the daytime pattern, but usually the biomass was distributed evenly.

ZOOPLANKTON SPECIES ABUNDANCE

Ong (1967) operated a Station off Pierson's Point at the mouth of the Derwent River for a period of 11 months and he studied the major surface zooplankton only, where the emphasis was on the relation to temperature, salinity and primary productivity. In the present study the three Stations were operated day and night and also at different depths to provide fuller information on the distribution and composition of the zooplankton.

The species found were classified into four groups using annual mean numbers recorded at any station as abundant, common, frequent and rare (abundant - $<101/10m^3$; common - $11\text{-}100/10m^3$; frequent - $1.1\text{-}10/10m^3$; rare - $>1.0/10m^3$).

For the major coastal species such as *Paracalanus parvus*, *Acartia clausi*, *Gladioferens inermis*, and *Euterpina acutifrons* and an estuarine species *Gladioferens pectinatus*, only surface water plankton samples were studied.

Amongst the coastal species, *Paracalanus parvus* and *Acartia clausi* were abundant; *Calanus australis*, *Centropages australiensis*, *Gladioferens inermis*, *Euterpina acutifrons* and *Sagitta guileri* were common species; and *Labidocera tasmanica* was found to be frequent.

A sole estuarine copepod, *Gladioferens pectinatus*, which was taken sporadically, was a frequent species.

The zooplankton species collected also contain a number of oceanic water origin, some being found in large numbers during some months of the year. These species can be accordingly classified as abundant, common, frequent and rare. *Neocalanus tonsus* was an abundant species whereas *Clausocalanus ingens*, *Ctenocalanus vanus*, *Oncaea media*, *Nyctiphanes australis*, *Sagitta minima*, *Sagitta serratodentata tasmanica* and *Salpa fusiformis* were frequent species.

The remaining species consisting of 23 of oceanic origin and 1 coastal, were found to be rare.

MAJOR ZOOPLANKTON SPECIES

COPEPODA

Paracalanus parvus (Claus)

A copepod species which dominated the plankton population throughout the year at Stations IC2 and IC3 (Fig. 7), the maximum mean total of $3425.0/m^3$ was observed at Station IC2 in September. However, the maximum number in a single plankton tow of $6417.1/m^3$ was recorded in the same month at Station IC2 from the night sample. The numbers taken were low, mean total less than $250/m^3$, at all the three Stations during October and from January to April. During the remaining months this species not only dominated the copepod population, but also the zooplankton population. Apart from a few occasions, the numbers found were greater at night compared with the corresponding day samples (Fig. 7).

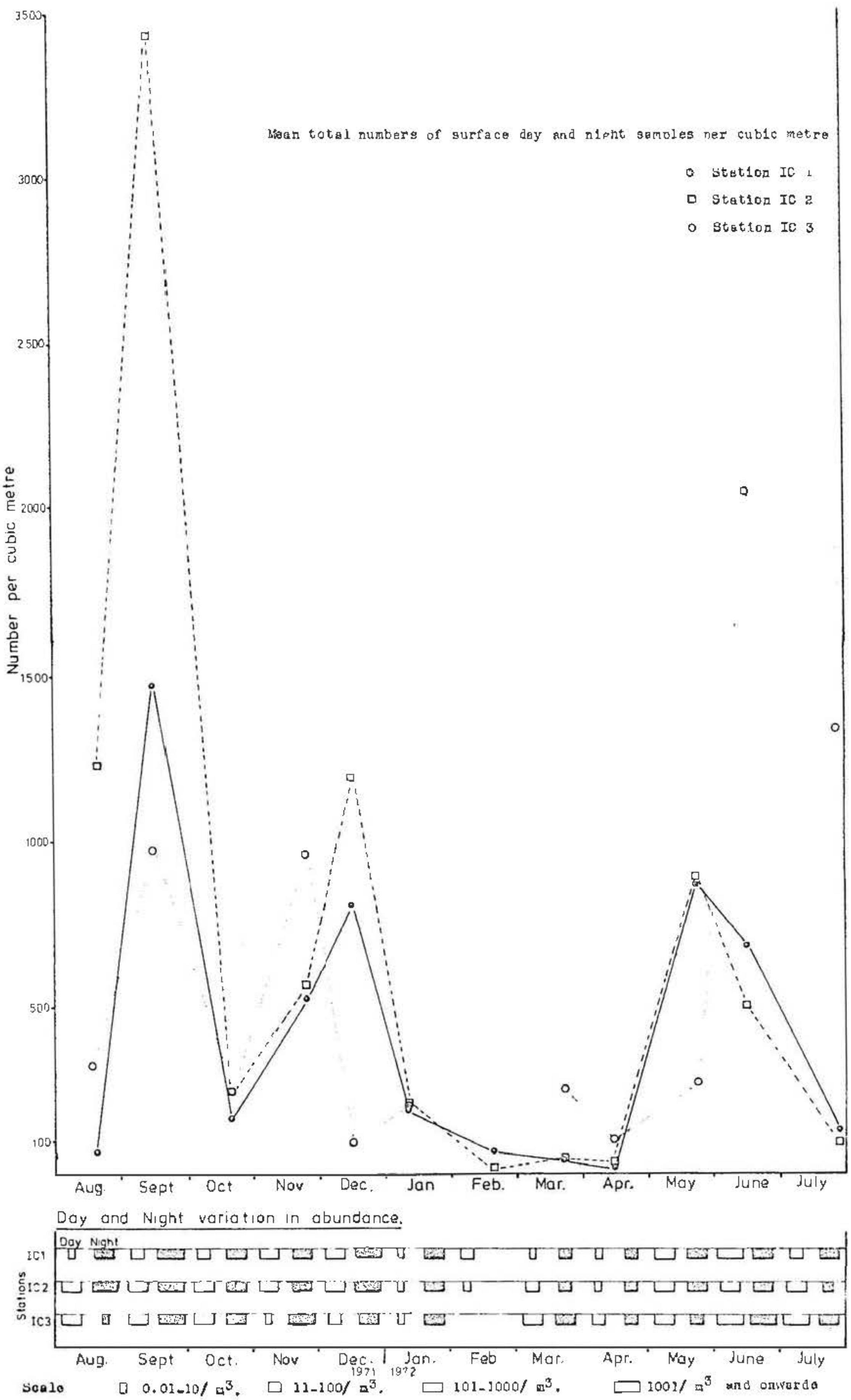


Fig 7 Seasonal abundance of Paracalanus parvus at surface waters of stations IC1, IC2 and IC3

This was a widespread coastal species off the East coast of Tasmania and has been considered as an indicator of such waters (see Section II). Ong's (1967) Station in the area of Station IC2, yielded Copepodites of Acartia clausi as a dominant copepod species. These specimens should be assigned to Paracalanus parvus (see description and discussion in Section I).

Dakin and Colefax (1933) found it to be the most common copepod in the coastal waters of New South Wales where a single peak in late Winter was observed. Jillett (1971) also considered it to be the most abundant copepod occurring throughout the year in the inshore waters of Hauraki Gulf, New Zealand. In this study it was taken in the Derwent River estuary as far up as the tidal zone (see Section IV).

Acartia clausi Giesbrecht

Dominant in the Station IC1 area from August to October and the most common copepod in July (Fig. 8). At Stations IC2 and IC3 the numbers taken were second to Paracalanus parvus. The numbers taken were generally high at all Stations from August to November, the maximum mean total of $1892.1/m^3$ being found at Station IC1 in September, and a maximum number in a single plankton tow of $3211.7/m^3$ was also recorded from the day sample at the same Station. During the remaining months the number was below $100/m^3$ at all Stations except in July, when the number increased to just over $200/m^3$ at Station IC1, but at Stations IC2 and IC3 the number was still below $100/m^3$. Diurnal variation in abundance is shown in Figure 8 when greater numbers were observed during night samples.

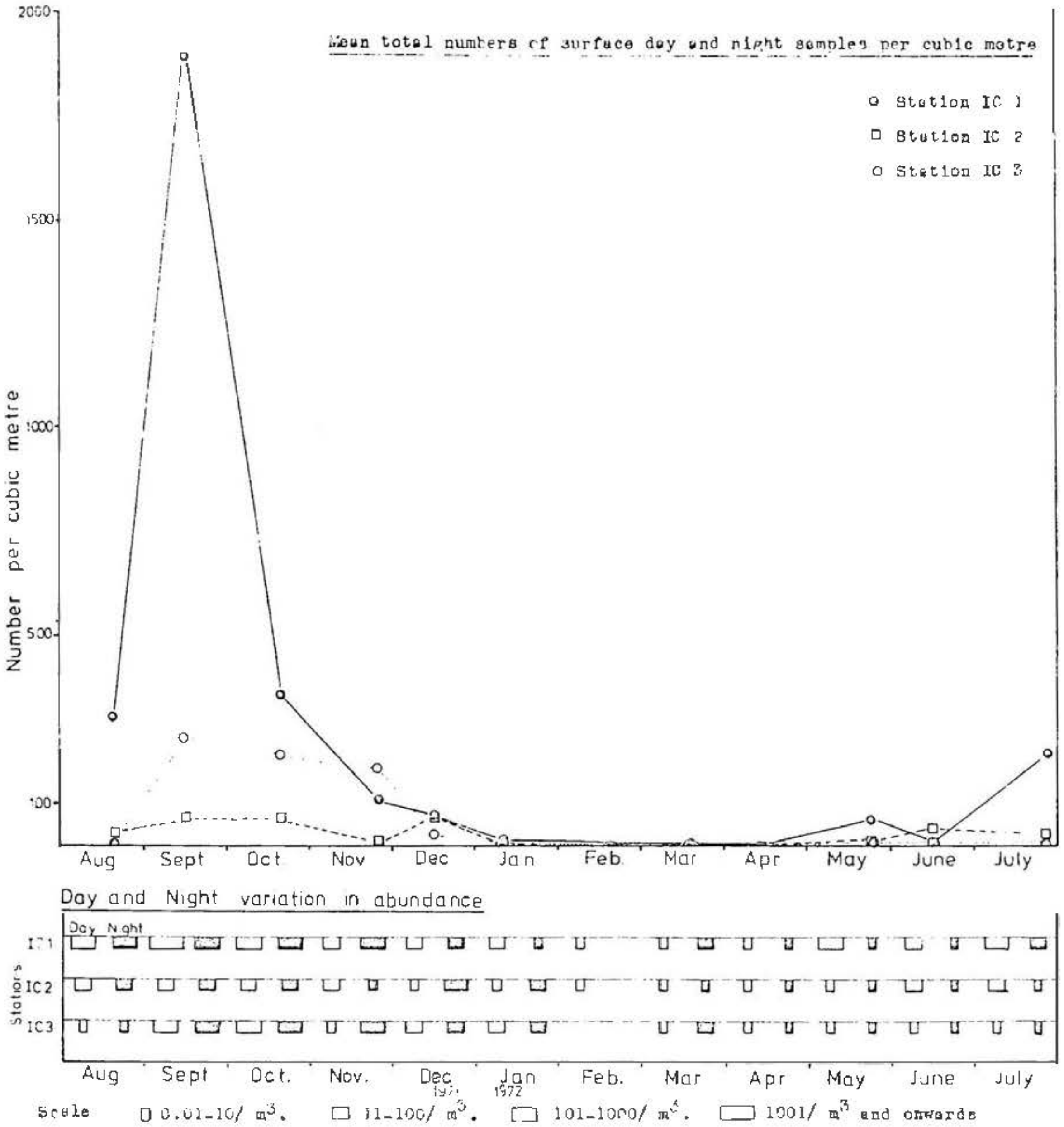


Fig. 8 Seasonal abundance of Acartia clausi at surface waters of stations IC1, IC2 and IC3

Off the East coast of Tasmania this species was found to be restricted to coastal waters and has been used as an indicator of such waters (see Section II). Ong (1967), recorded a maximum of adults of this species in May, reaching to $10943.2/m^3$ in the area of the Station IC2, during the remaining months the number was low, less than $150/m^3$. His results do not agree with the present results, where generally large numbers of greater than $150/m^3$ were found from September to November at Station IC2.

Dakin and Colefax (1933) found this species to be as equally abundant as *Paracalanus parvus* in the coastal waters of New South Wales, where a major peak in October-November was observed. This peak is similar to the peak encountered in September at Station IC1. Jillett (1971) found it to be an abundant species, although in less numbers than *P. parvus* in inshore coastal waters of Hauraki Gulf, New Zealand, which is very similar to the present area.

Calanus australis Brodsky

A common species occurring throughout the year at all three Stations although the number taken was greater and more consistent at Station IC3 compared with the remaining two Stations where the number fluctuated from month to month (Fig. 9). The maximum mean total of $118.7/10m^3$ was observed in December when Stage V copepodites outnumbered the adults at Station IC3. During the same month at this Station a maximum number of $442.1/10m^3$ was recorded from the night sample at surface waters. Seasonal diurnal vertical distribution of this species is shown in Figure 15 where it appeared to avoid direct sunlight during summer months. This is clearly illustrated at Station IC1 where the collecting time was consistent (Fig. 6).

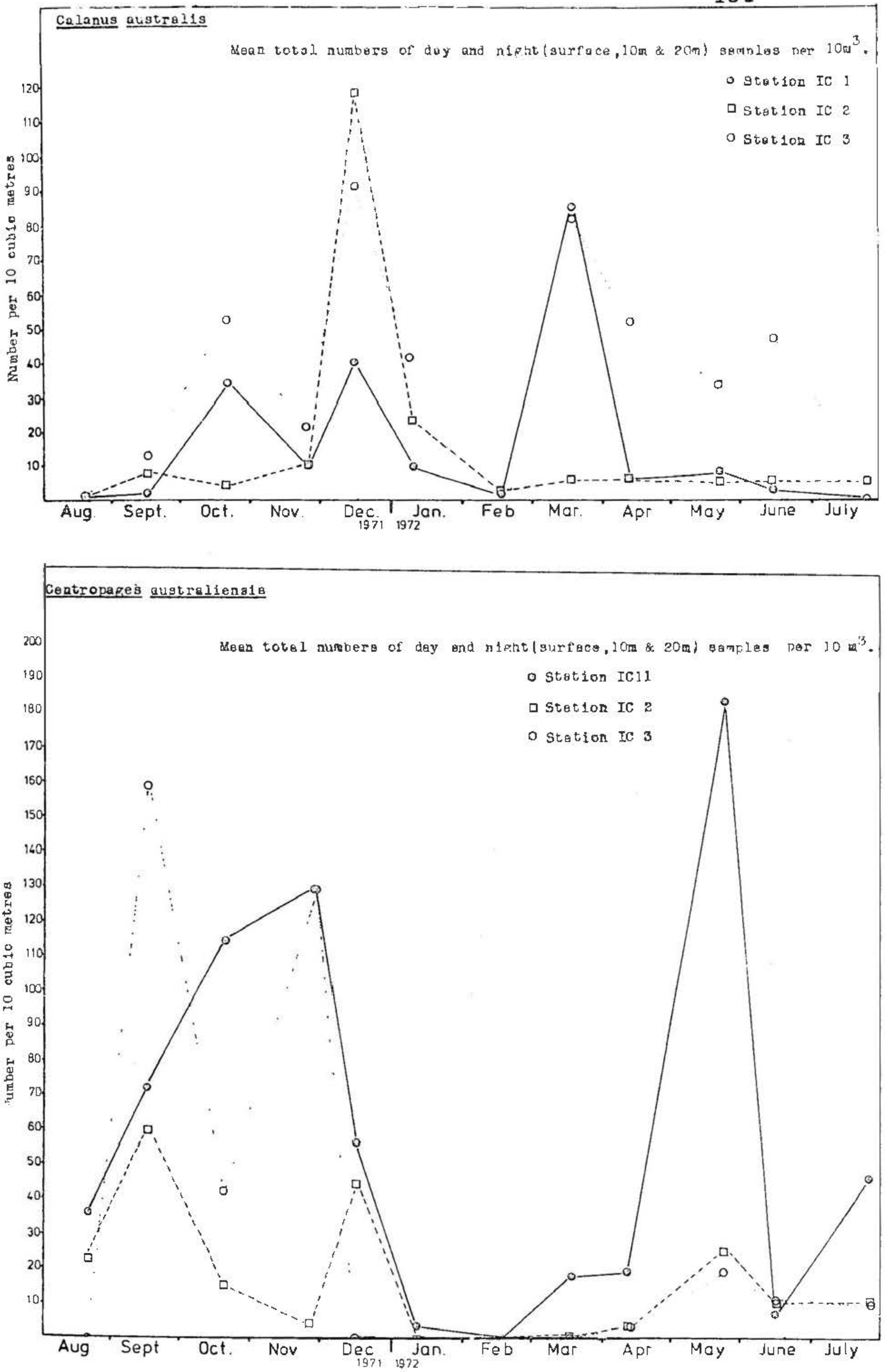


Fig. 9 Seasonal abundance of Calanus australis and Centropages australiensis at stations IC1 IC2 and IC3

Ong (1967) listed its rare occurrence as Calanus helgolandicus in Appendix II, Table II, although he did not mention it in the text. On the East coast of Tasmania, it was found to be widespread in distribution, the numbers being greater in coastal waters (see Section II). Dakin and Colefax (1933) found it (as Calanus finmarchicus) to occur throughout the year in low numbers. Jillet's (1971) findings of the species at Hauraki Gulf, New Zealand, are similar to the results in this study. He found the species to be common, occurring throughout the year at Jellicoe Channel, but on a few occasions, found it at Waitemata Harbour.

Centropages australiensis Fairbridge

A common coastal copepod species taken throughout the year except February (Fig. 9). Comparatively, it was more common at Stations IC1 and IC3, the maximum mean total of 183/10m^3 being observed in May at Station IC1. The maximum number in a single sample (381.2/10m^3) was recorded at the same Station from 20m depth sample collected at night. Generally, it was common from August to December and the number decreased to less than 20/10m^3 from January to April. Large numbers were encountered again especially at Station IC1 in May, but from June onwards, the number found was low.

The seasonal diurnal vertical distribution of this species is shown in Figure 15, where no apparent either vertical distribution or diurnal variation was observed.

Ong (1967) observed a single maximum in May (as Centropages kroyeri Hobart form). Dakin and Colefax (1940) had taken this species (as Centropages kroyeri Sydney form) only once during the night haul in November, although it was reported in south-eastern Australian coastal waters by Kott (1957) and Vervoort (1964).

Off the East coast of Tasmania it was a common species, restricted to coastal waters and considered as an indicator of such waters.

Gladioferens inermis Nicholls

Taken at all three Stations, the numbers being higher at Stations IC1 and IC2 than at Station IC3 (Fig. 10). A maximum mean total of $256.8/10m^3$ was recorded at Station IC1 in November. The number found was greater during night samples.

Nicholls (1944) found this species together with Pseudodiaptomus cornutus at Blanche Harbour and stated that the salinity at the Harbour is presumably lower than that of ordinary sea water, judging by the presence of G. inermis in the same collection. Bayly (1963) thought that G. inermis was probably an euryhaline species, ecologically similar to G. pectinatus and that it was probably collected close to the upper limit of its salinity range from an open system by Nicholls. Arnott and Hussainy (1972) found it at the mouth of the Werribee River where the salinity was usually above 34.0‰ together with marine species and concluded that the species is inshore marine in distribution.

However, although it was found almost throughout the year at all Stations, the number taken was greater during low salinity periods and at Stations IC1 and IC2 than at Station IC3, suggesting that it is an inshore marine species which prefers lower salinity waters than full strength coastal sea waters.

This was supported by its occurrence as far upstream as the marine end of the gradient zone in the Derwent River where the surface salinity was 11.03‰ (bottom salinity - 23.18‰) (see Section IV).

G. inermis was taken together with P. cornutus but unlike P. cornutus it was not restricted to the Stations IC1 and IC2. Nicholls (1944) also found the association of this species with P. cornutus.

Gladioferens pectinatus (Brady)

Occurred sporadically mainly at Stations IC1 and IC2 (Fig. 10). Maximum mean total of $18.94/10m^3$ was recorded at Station IC1 in November.

It is no doubt an estuarine indicator, but the presence in small numbers, of this species, in inshore coastal or coastal environments, has been previously noted by Bayly (1965), Ong (1967), Jillett (1971) and Arnott and Hussainy (1972). Since it is a common estuarine species, usually found in abundant numbers in Australian river estuaries (Bayly, 1963; Neale and Bayly, 1974), there is no definite way of knowing whether the specimens originated in the River Derwent or in other estuarine sources such as Frederick Henry Bay or other small estuaries along the coast.

Labidocera tasmanica Nyan Taw

Occurred almost throughout the year at all three Stations (Fig. 12). The number taken was greater at Stations IC1 and IC2. Generally two maxima were observed, one in November and the other in May. Figure 15 shows the seasonal diurnal vertical distribution where the number found was greater during night samples compared with the day samples.

Off the East coast of Tasmania it was found sporadically in inshore coastal waters (see Section II). This seems to suggest that it is a species which inhabits shallow inshore coastal waters.

Euterpina acutifrons (Dana)

Occurred at all three Stations and like G. inermis, the number found was usually greater at Stations IC1 and IC2 than at Station IC3 (Fig. 10). Maximum mean total number of $148.43/10m^3$ was recorded in May, at Station IC2.

Dakin and Colefax (1933) encountered this species almost throughout the year, but common during Winter months off the New South Wales coast. Jillett (1971) found it has the tendancy to be abundant during the time of low temperature and salinity and considered it to represent inshore waters at Hauraki Gulf, New Zealand.

Since it was taken throughout the year and in greater numbers at Stations IC1 and IC2 and by the fact that it was present in much reduced salinity waters (surface salinity - 5.43‰; bottom salinity - 12.40‰) of the gradient zone in the Derwent River estuary (see Section IV) suggests the species to be inshore marine, which has a wide range of salinity tolerance.

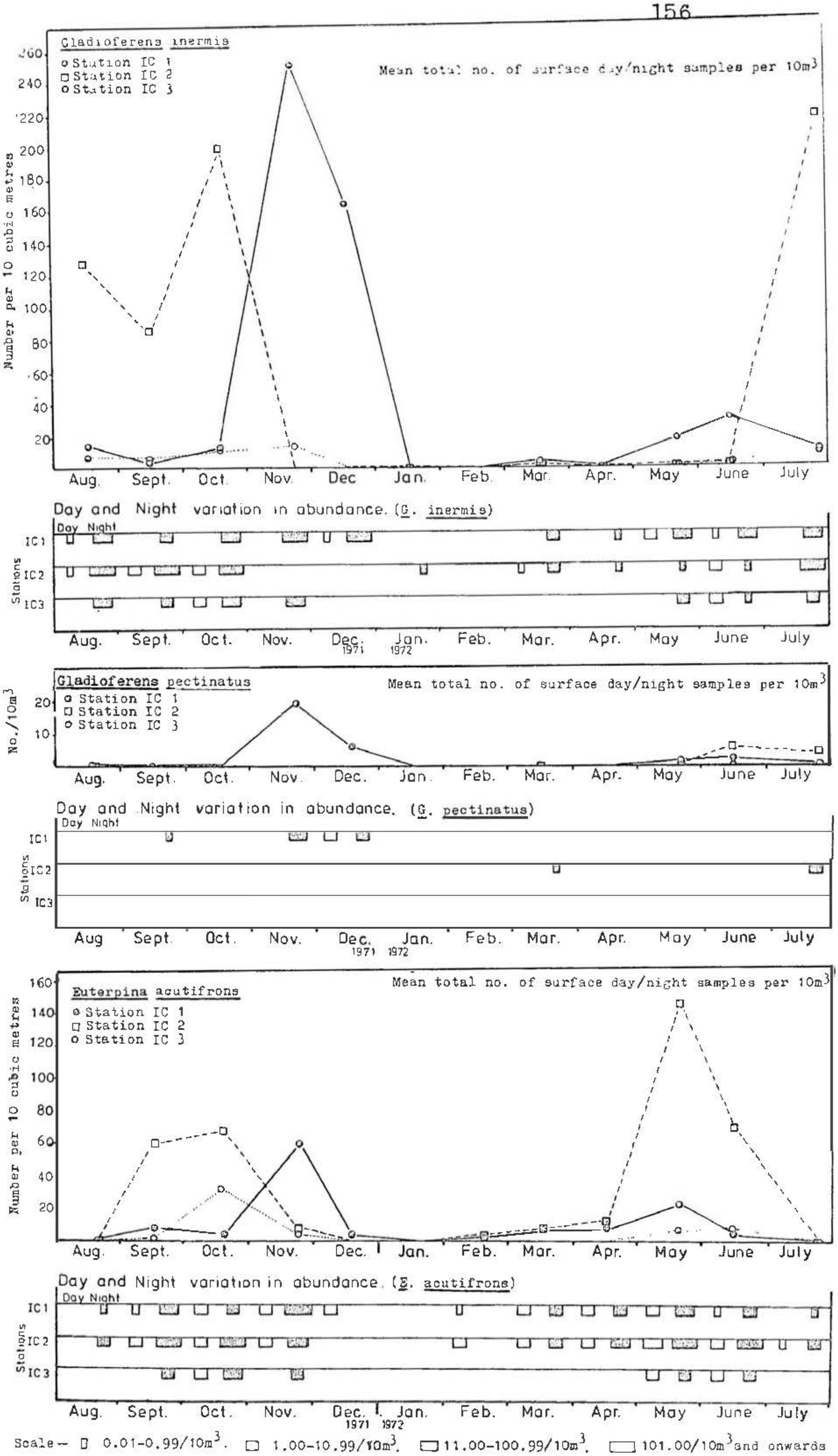


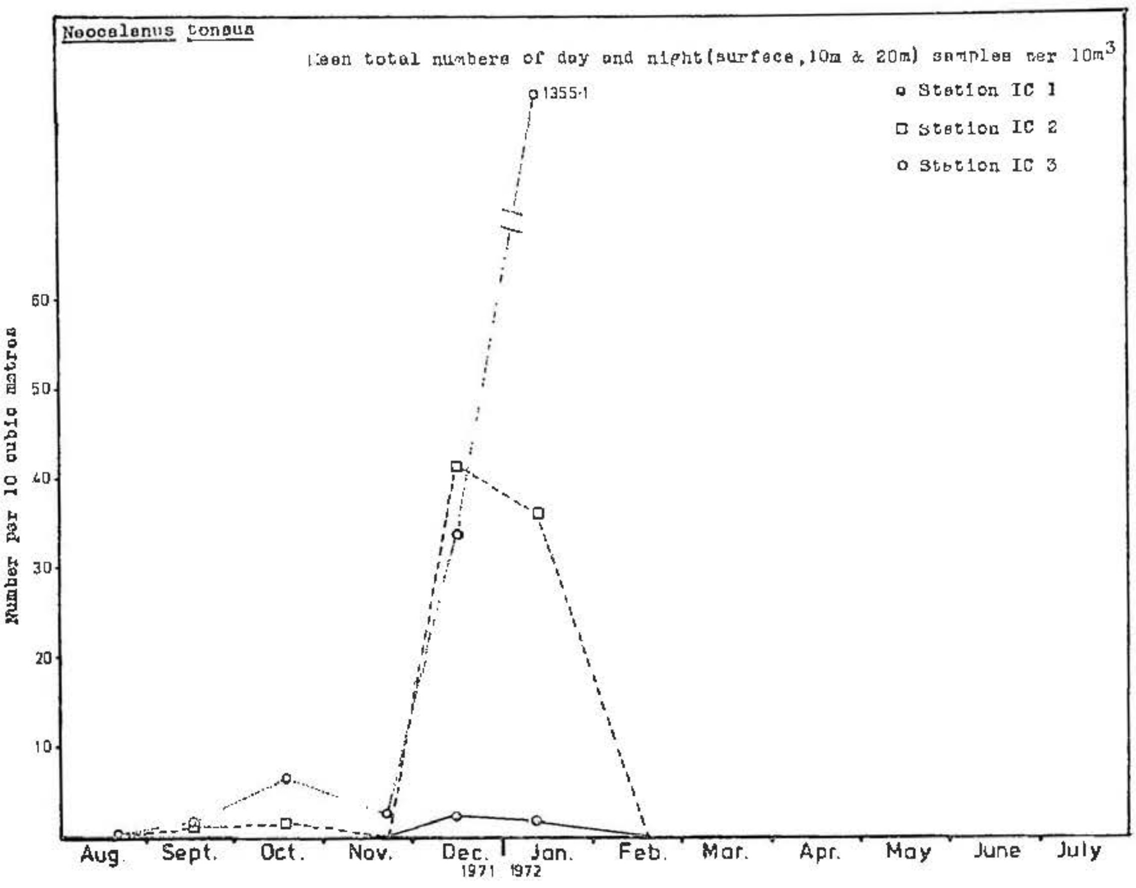
Fig.10 Seasonal abundance of Gladioferens inermis, Gladioferens pectinatus and Euterpina acutifrons at surface waters of stations IC1, IC2 and IC3.

Neocalanus tonsus (Brady)

The most abundant oceanic copepod species found in the present study, mainly at Stations IC2 and IC3 (Fig. 11). The specimens consisted mainly of copepodite Stage V. A few specimens were taken in August at Station IC3 and gradually the number increased, reaching a maximum mean of $1355.1/10m^3$ in January, when a maximum of $4040.3/10m^3$ in a single tow, was recorded during the surface night tow. It was also found at Station IC2, but in lesser numbers and the maxima being in December. At Station IC1 it was present only in December and January and in low numbers. From February onwards to the end of the study period in July, none were taken.

The seasonal diurnal vertical distribution is given in Figure 15. Like the open coastal species, Calanus australis, it seems to be sensitive to sunlight as a few or none were taken at the surface water during daylight tows.

The most abundant and dominant oceanic copepod species found generally from August to December off the East coast of Tasmania associated with Sub-antarctic waters (see Section II). Similar occurrences had been reported by Jillett (1968) and Bradford (1972) from waters off the central East coast of New Zealand. Roberts (1972) found adult females and Stage V copepodites in large numbers at Perseverance Harbour, Campbell Island from October to March. Its tolerance to temperature and salinity has been discussed in Section II, where Stage V copepodites had a wider range than the adult females. Since it was taken at the time when the East coast was influenced by Sub-antarctic waters, its appearance would indicate such influence in the area.



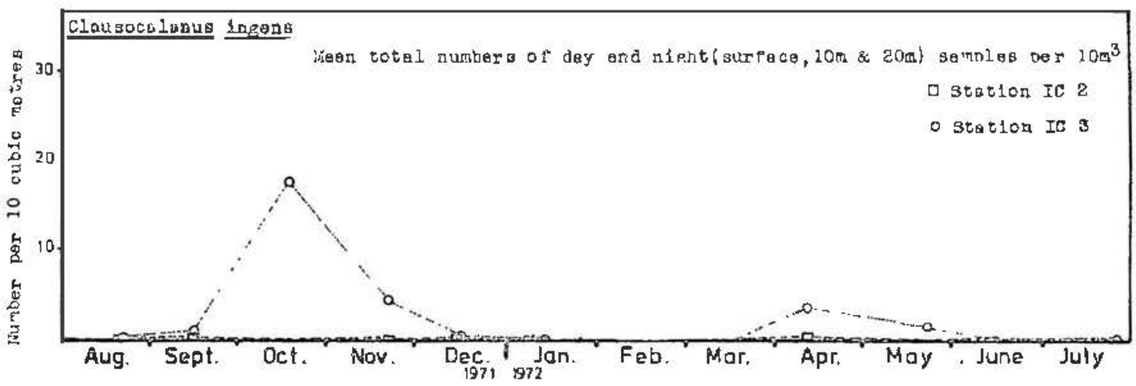


Fig.11 Seasonal abundance of Neocalanus tonsus and Clausocalanus ingens at stations IC 1, IC 2 and IC 3

Clausocalanus ingens Frost and Fleminger

Apart from the February samples, it was present in all months in small numbers, mainly at Station IC3, where a maximum mean of $17.2/10m^3$ was observed in October (Fig. 11). Less than $1.0/10m^3$ was taken during some months at Station IC2, but none was found at Station IC1. Seasonal diurnal vertical distribution is given in Figure 15, where no apparent variation is found.

It is regarded as a local oceanic species, found all year round sometimes in large numbers off the East coast of Tasmania (see Section II). The appearance of this species would indicate the influence of oceanic waters.

Ctenocalanus vanus Giesbrecht

Apart from the January and February samples, it was found at all three Stations throughout the study period (Fig.12), the numbers taken being greater during the night tows compared with corresponding day tows (Fig. 15). During the day tows the surface waters were mainly devoid of this species.

It was taken sporadically off the East coast of Tasmania mainly in coastal waters (see Section II). Jillett (1971) also found it almost throughout the year at Jellicoe Channel, but present at Waitemata Harbour station, New Zealand, on a few occasions only. He regarded it as an oceanic species which was introduced from the outer gulf area in the Jellicoe Channel, being unable to maintain itself in the neritic (Waitemata Harbour) habitat.

The present area is comparable to that of Jelicoe Channel as C. vanus was found almost throughout the year which suggested

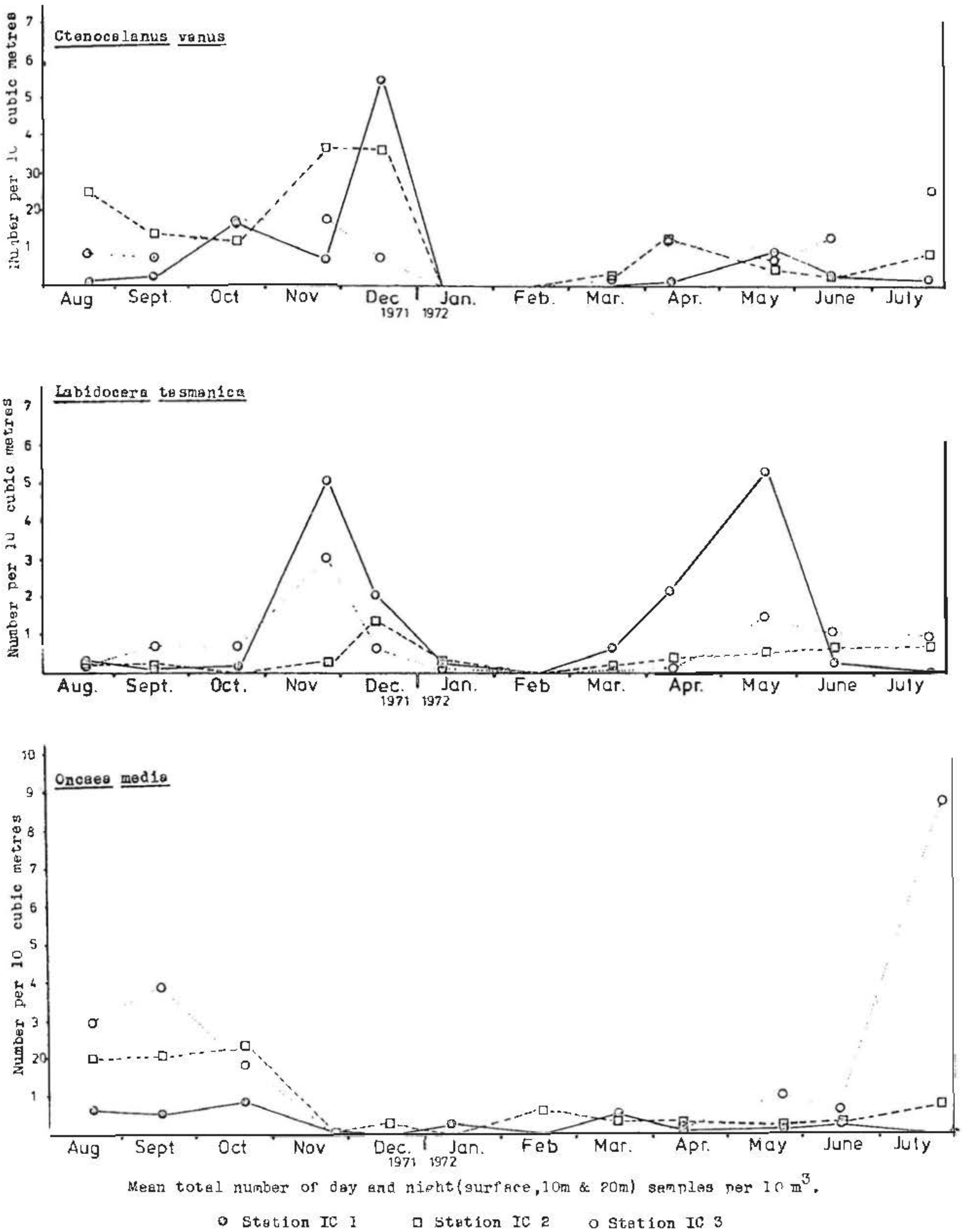


Fig.12 Seasonal abundance of Ctenocalanus vanus, Labidocera tasmanica and Oncaea media at stations IC1 IC2 and IC3

that although introduced from the East coast, it seemed to be able to maintain and survive in the inshore environment.

This was later evident by its presence further upstream in the Derwent River to the region near the tidal zone (see Section IV).

Oncaea media Giesbrecht

Occurred at all three Stations and at Station IC2 it was found almost throughout the year. The number found was greater from August to October and in July, during the remaining months the number taken was low (Fig. 12). Diurnal variation in catchability was not apparent, however, there was evidence of variation in vertical distribution where the number increased with depth and in some cases, usually summer months, the surface waters were devoid of this species (Fig. 15).

It was found off the East coast of Tasmania and has been considered as one of the indicators of inshore Sub-tropical oceanic waters (see Section II). Finding this species persistently at Stations IC1 and IC2 suggests that although initially brought into the inshore area, it could maintain itself in the inshore habitat. A similar result was found by Jillett (1971), where it occurred at Jellicoe Channel almost throughout the year, but was present only once at Wiatemata Harbour, Hauraki Gulf, New Zealand.

EUPHAUSIACEA

Nyctiphanes australis Sars

The only Euphausid species found in the present study area, although a few oceanic species have been recorded off the East coast of Tasmania (see Sections I and II). The occurrence of this species is given in Figure 14, where maximum mean of 19.6/10m^3

was found in December at Station IC2 for adults. It was taken mainly during the night samples (Fig. 15). Calyptopis and Furcitia larvae of this species were found throughout the year, sometimes dominating the non-zooplankton population (see page 175 The adults were encountered sporadically in coastal waters off the East coast of Tasmania (see Section II). Ong (1967) listed this species in Appendix I, Table II, as having been found in small numbers in April, June, July and November, but did not mention it in the text.

This species is common in coastal waters of southeastern Australia and New Zealand, with the occurrence of large numbers of larval stages in the inshore waters, suggesting that the species breeds in those waters.

CHAETOGNATHA

Sagitta guileri Nyan Taw

A dominant Chaetognath found at Station IC1, occurring almost throughout the year (Fig. 13). Being taken in large numbers, usually during night plankton tows, generally from November to January. It was also taken at Station IC2, but in lesser numbers. However, at Station IC3 it was encountered only twice - in September and November.

The distribution of this species based on daylight oblique tows as well as night tows in the waters south-east of Tasmania, was given by Nyan Taw (1975a), who found that it occurred as far upstream as off the Zinc Works in the Derwent River, the area where the surface salinity was 15.91‰ (bottom salinity - 32.44‰) (see Section IV).

It appears that it is an inshore coastal species, so far the only coastal Chaetognath in Australian waters, which seems to be restricted to inshore areas of southeastern Tasmania.

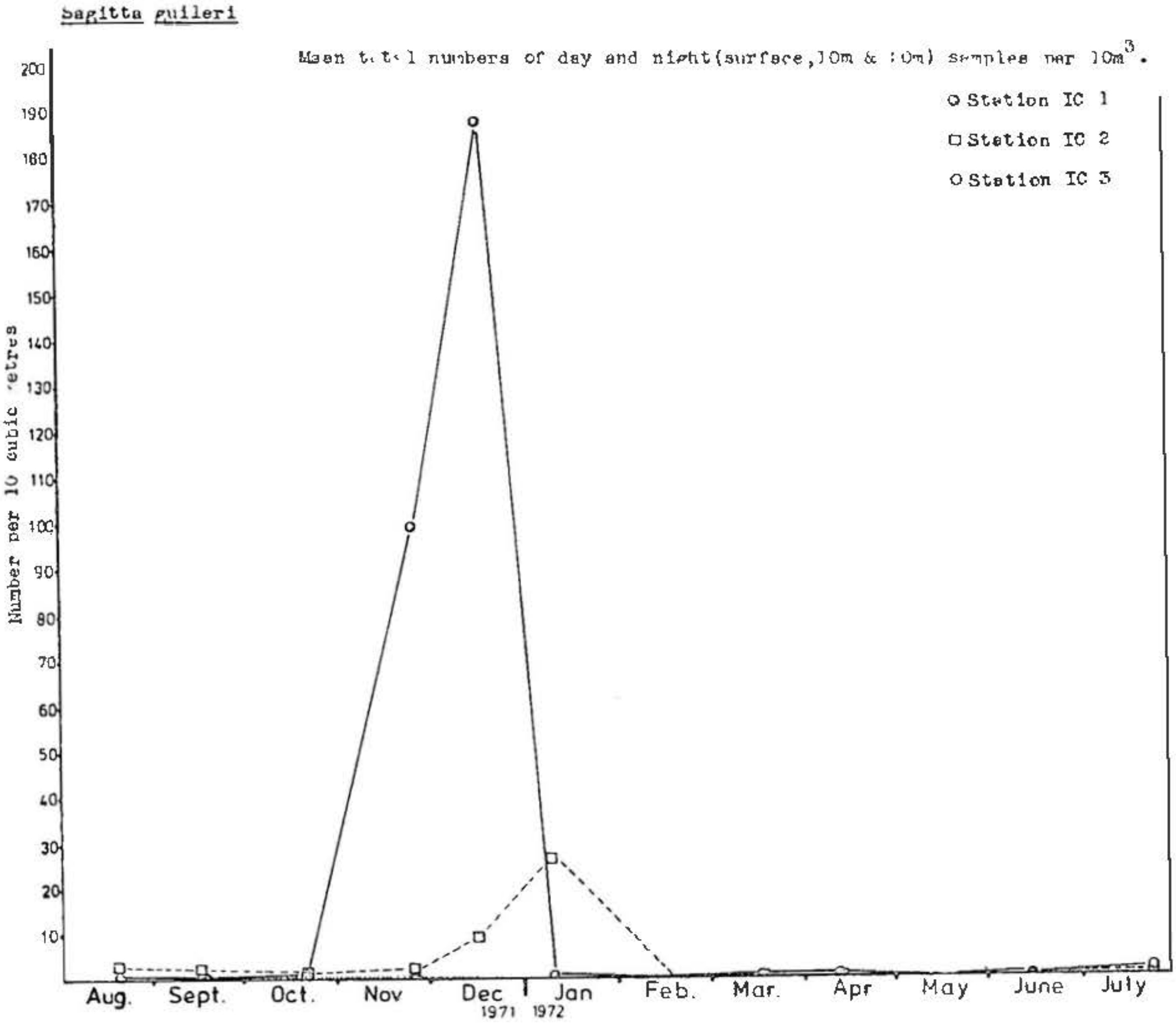
<u>Sagitta</u> <u>minima</u> Grassi

The occurrence of this species is shown in Figure 13 where it was taken at all three Stations. Maximum mean number of $15.0/10m^3$ was taken in August at Station IC3. Apart from the July sample at Station IC3 where the number encountered was $4.4/10m^3$ the number taken during the remaining months was usually below $1.0/10m^3$ (Fig. 13). It was usually absent or the number found was lesser at surface than at sub-surface waters and no apparent diurnal variation in number was observed (Fig. 15).

It was a common species in warm oceanic and coastal waters off the East coast of Tasmania (see Section II). In the present study it appeared to be introduced from the East coast into the inshore area, with some being able to maintain themselves in the neritic habitat.

<u>Sagitta</u> <u>serratodentata</u> <u>tasmanica</u> Thomson

The occurrence of this species is given in Figure 14. It was generally taken from August to January, when a substantial number was found at all three Stations in December, reaching a maximum mean of $38.0/10m^3$ at Station IC3 in January. A high number of $14.8/10m^3$ was observed again at Station IC3 in July. The number taken was greater during the night samples compared with the corresponding day samples and it usually was found in the night tows (Fig. 15).



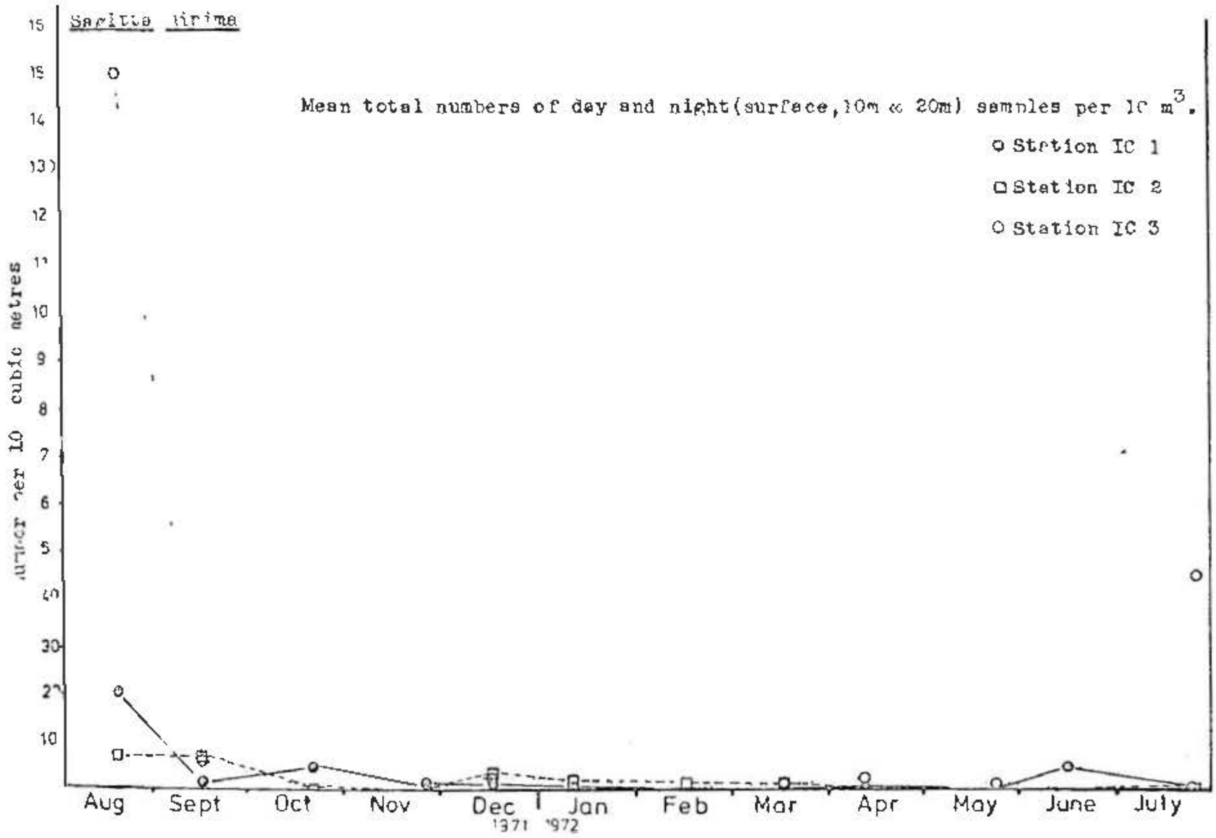


Fig 13 Seasonal abundance of Sagitta guileri and Sagitta minima at stations IC1, IC2 & IC3

A widely distributed oceanic species off the East coast of Tasmania and is considered to be a local oceanic indicator (see Section II). The appearance of it in the inshore area would indicate the influence of oceanic waters.

PELAGIC TUNICATA

Salpa fusiformis

Taken in large numbers, dominating the plankton sample in February at Stations IC1 and IC2, when the mean total numbers were 32.1/10m^3 and 40.0/10m^3, respectively, (Fig. 14). The maximum in a single plankton tow was recorded as 224.0/10m^3 at Station IC2 collected from 20m depth during daylight hours. In March it was taken only at Station IC3 in low numbers. All specimens were taken from sub-surface samples only (Fig. 15).

This was the only species of Pelagic Tunicate found in the area. The only Pelagic Tunicate found by Ong (1967) were Appendicularia which was probably due to the nature of his study whereby he sampled only the surface waters. *Salpa fusiformis* was one of the common Pelagic Tunicate found off the East coast of Tasmania and has been found to indicate warm, Sub-tropical waters (see Section II). As such, its invasion into the inshore area suggests a strong influence of Sub-tropical oceanic waters.

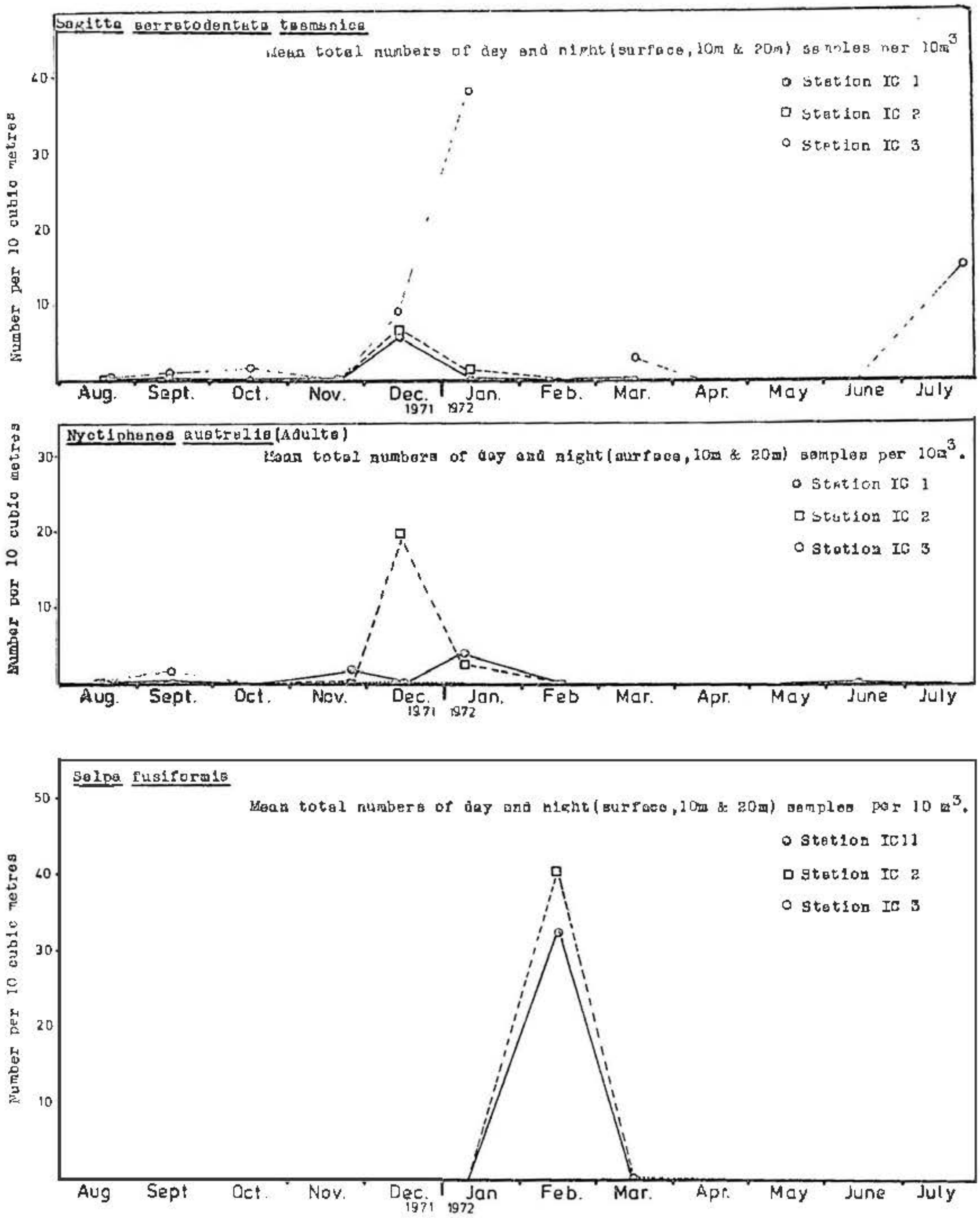


Fig.14 Seasonal abundance of Sagitta serratodentata tasmanica, Nyctiphanes australis and Salpa fusiformis at stations IC1, IC2 and IC3.

MINOR ZOOPLANKTON SPECIES

COPEPODA

Calanoida

Calanidae

Calanoides carinatus (Kroyer) was found during the night samples in December at all three Stations, however, in January it occurred only at Station IC3 in sub-surface waters, also at night (Fig.15). An abundant species off the East coast of Tasmania in oceanic waters from August to December (see Section II).

Mesocalanus tenuicornis (Giesbrecht) occurred sporadically mainly in sub-surface waters at Stations IC2 and IC3 only (Fig. 15). It was also found sporadically both in coastal and oceanic waters off the East coast of Tasmania (see Section II).

Eucalanidae

Mecynocera clausi Thompson occurred sporadically at all the three Stations, most frequently from August to December (Fig. 15). Off the East coast of Tasmania it was found to be widespread in distribution, being found in both coastal and oceanic waters (see Section II). This unusual ability to tolerate extreme environmental changes was later evident by its presence in the Derwent River estuary as far upstream as off the Zinc Works, a tidal zone, where the surface salinity was 15.91‰ (bottom salinity - 32.44‰) (see Section IV). Jillett (1971) also found it to occur almost throughout the year at Jellicoe Channel, Hauraki Gulf, New Zealand.

Paracalanidae

Three species - Calocalanus styliremis Giesbrecht, Calocalanus tenuis Farran and Leptocalanus plumulosus (Claus)- were taken in the area (Fig. 15).

C. styliremis was found at Station IC2 and IC3 whereas C. tenuis occurred at all the three Stations. L. plumulosus was was present at Station IC3 in the April collection only.

All the three species were found off the East coast of Tasmania (see Section II). C. styliremis was associated with Sub-antarctic waters, whereas L. plumulosus was considered as a Sub-tropical water indicator (see Section II). C. tenuis was a widespread species and is considered as a local oceanic species.

Pseudocalanidae

The species taken from this family were - Clausocalanus arcuicornis (Dana), Clausocalanus jobei Frost and Fleminger, Clausocalanus mastigophorus (Claus) and Clausocalanus parapergens Frost and Fleminger (Fig. 15).

C. arcuicornis occurred only at Stations IC2 and IC3 and was the most frequent occurring species amongst the Clausocalanus species. Similarly, C. jobei and C. mastigophorus were restricted to Stations IC2 and IC3. However, C. parapergens was present at all the three Stations although found only in May and June.

The only species found elsewhere in Tasmania, but not encountered here is Clausocalanus brevipes Frost and Fleminger, which was recorded on the East coast of Tasmania.

Aetideidae

A sole adult female specimen of Euchirella rostrata Vervoort was taken in August at Station IC2 (Fig. 15). It was a common species which has been regarded as an indicator of Sub-antarctic waters off the East coast of Tasmania (see Section II).

Scolecithricidae

A specimen each of Racorvitzanus sp? and Scolecithrix danae Lubbock were captured in December and August respectively, at Station IC3.

Racorvitzanus sp? was not taken off the East coast of Tasmania whereas S. danae was a rare species (see Section II).

Centropagidae

Centropages bradyi Brady occurred from August to December, taken mainly at Station IC2. From January onwards, none were found until in June and July when substantial numbers were found mainly at Stations IC2 and IC3 (Fig. 15).

It was probably brought into the inshore area from the East coast where it was widespread in distribution.

Metridiidae

A single female specimen of Metridia lucens Giesbrecht was captured in June during the surface night plankton tow.

Amongst the two species of *Pleuromamma*, *P. abdominalis* (Lubbock) was taken only once in July at Station IC3, whereas *P. gracilis* (Claus) was found from May to July at Stations IC2 and IC3 (Fig. 15). Both these species have been recorded on the East coast and have been considered as indicators of Sub-tropical waters (see Section II).

Pseudodiaptomidae

Pseudodiaptomus cornutus Nicholls was taken at Stations IC1 and IC2 only and usually the number taken during night plankton tows was greater (Fig. 15) than in the daytime.

Lucicutiidae

A single female specimen of *Lucicutia flavicornis* (Claus) was captured in September at Station IC2 (Fig. 15).

Heterorhabdidae

Only one female specimen of *Heterorhabdus papilliger* (Claus) was taken in September at Station IC3 (Fig. 15).

Candaciidae

Candacia bipinnata (Giesbrecht) was encountered twice, a female specimen in September and a male in July, both being taken at Station IC3 (Fig. 15). It was a common species and has been regarded as an indicator of sub-tropical waters of the East coast of Tasmania (see Section II).

Pontellidae

A single female specimen of Labidocera cervi Kremer was captured in February at Station IC1. Its occurrence was very unusual as it was not found on the East coast of Tasmania. However, absence of this species on the East coast could possibly be due to lack of summer samples, since a number of specimens were found in a plankton sample taken in February, 1974 at Robert's Point, D'Entrecasteaux Channel by Mr. D.C. Wolfe (see Section I). It could have been brought down from the North by the Sub-tropical waters.

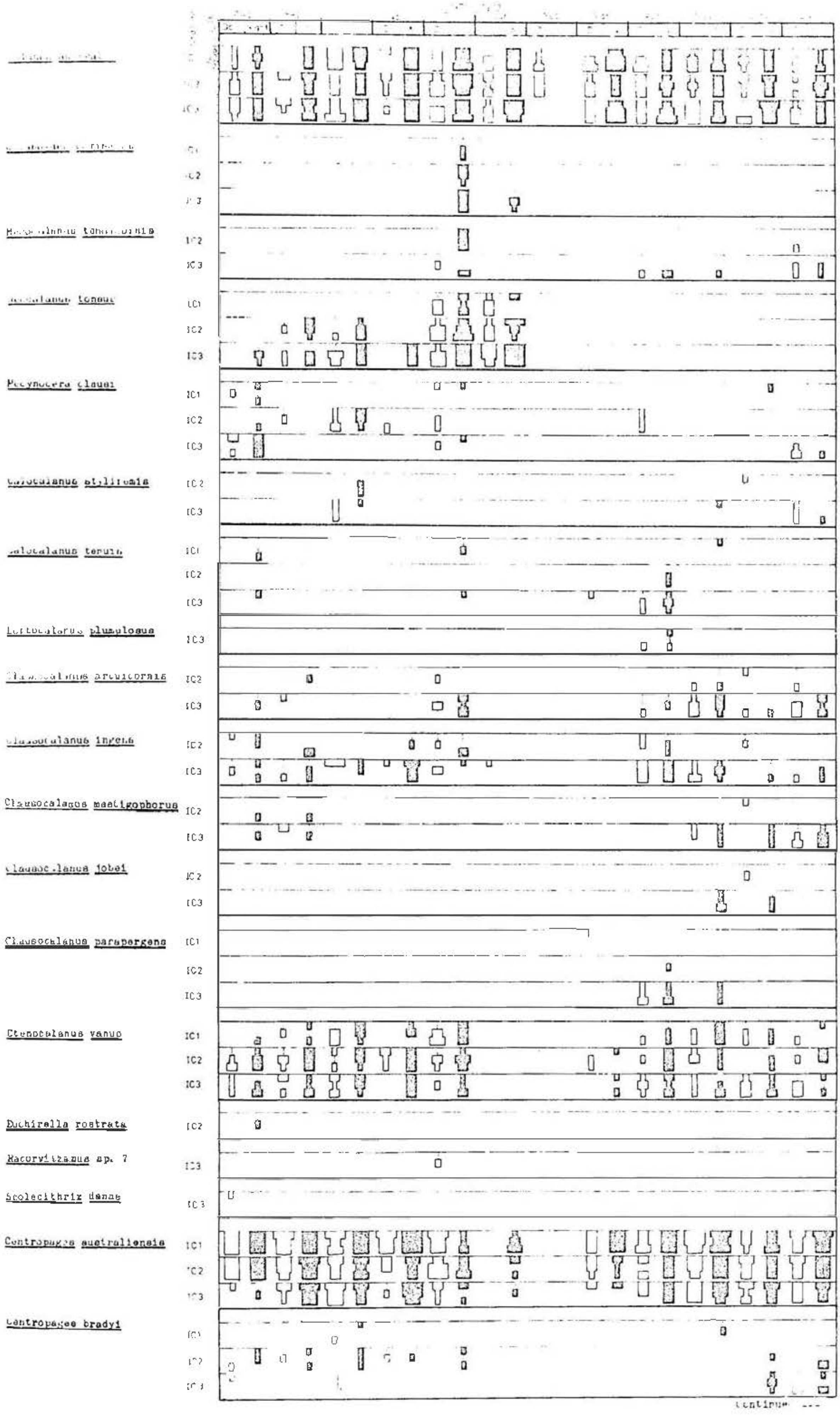
Acartiidae

Acartia danae Giesbrecht was taken only at Stations IC2 and IC3, its occurrence being concentrated to August-September and April-May (Fig. 15). A widespread species off the East coast of Tasmania, usually found in large numbers in warm waters (see Section II).

Cyclopoida

Oncaeidae

Oncaea venusta Phillippi was taken only in September at Stations IC2 and IC3 (Fig. 15). A common species off the East coast of Tasmania and has been regarded as indicator of Sub-tropical waters.


Peсynocera clausi
Calocalanus styliremis
Calocalanus tenuis
Clausocalanus arcuicornis
Clausocalanus ingens
Clausocalanus mastigophorus
Clausocalanus jobei
Clausocalanus parapergens
Ctenocalanus vanus
Euchirella rostrata
Racovitzanus sp. 7
Scolecithrix danae
Centropages australiensis
Centropages bradyi
IC1
IC2
IC3

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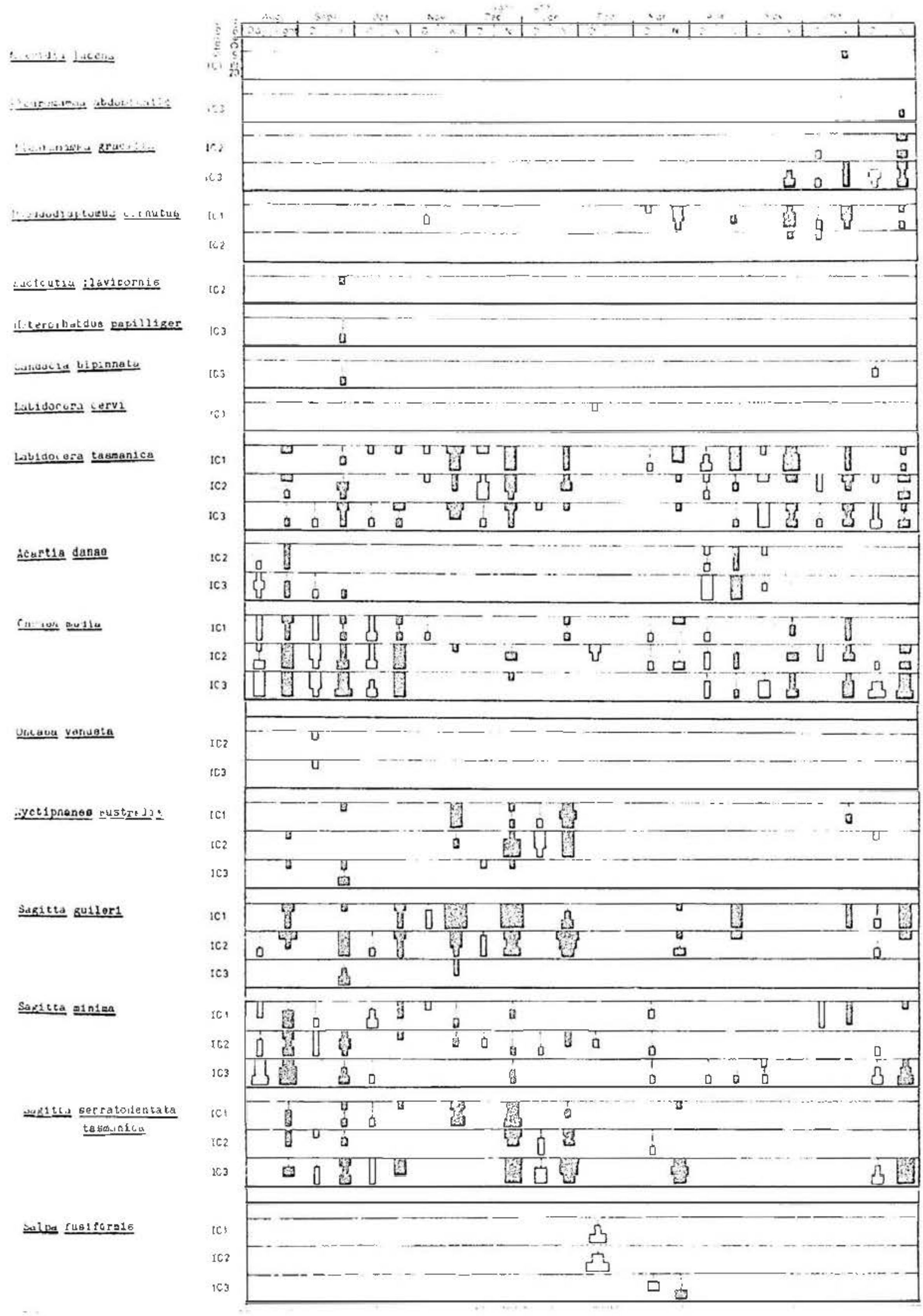

Scale... ▫ 0.01-0.99/10 m^3 ▫ 1.00-10.99/10 m^3

▭ 11.00-100.99/10 m^3 ▭ 101.00/10 m^3

Fig.15 - Seasonal diurnal vertical distribution of Zooplankton at Stations IC1, IC2 and IC3.

SEASONAL COMPOSITION OF MAJOR ZOOPLANKTON AT STATION IC2

Ong (1967) studied the seasonal composition of the major zooplankton from surface waters collected during daylight hours, off Pierson's Point, mouth of the Derwent River. Since the abundance of zooplankton varies considerably between day and night, zooplankton collected at surface waters during day and night at Station IC2 was studied, the Station being in the same position as Ong's Station. The average of both day and night samples was considered. The zooplankton groups with high numbers were studied separately, while the minor zooplankton were grouped together (Figs. 16, 17 and 18).

Copepods averaged 71.81% of the total zooplankton population for the whole study period of 12 months. The percentage was high, between 90% and 97% for three-quarters of the year. From January to April it dropped and the minimum of 24% was observed in April (Fig. 16).

Paracalanus parvus dominated in the copepod population in all months with the annual average of 87.9% and the percentage ranged from 64% to 97%. The remaining copepod species arranged in order of average annual percentage were:-

Acartia clausi

Gladioferens inermis

Oithona spp.

Euterpina acutifrons

Centropages australiensis

Calanus australis

All these species except _G. inermis_, were found almost throughout the year. _Acartia clausi_ reached a maximum of 19% in October, but during the remaining months, the percentage of this species was usually below 10%.

A high composition of 6% and 15% was found in October and July respectively, for _G. inermis_, a sole marine species from the genus _Gladioferens_. It was absent from November to February and only a low composition was observed from March until July when a high composition was found.

Oithona spp. were present in all months with a maximum composition of 4.3%. A large number was found from January to July. _Euterpina acutifrons_ was the most common Harpacticoid encountered in the present study. A high composition of 3.8% was observed in April and in October and from February to June a smaller proportion of between 1% and 2.7% was found. A very low composition was observed during the remaining months except in December, January and July inclusive, when it was absent. _Centropages australiensis_ represented up to 1.5% but usually in smaller proportions although found throughout the year except in February, the largest percentage of _Calanus australis_ (1.6%) was found in December, but usually the composition observed was low, though relatively moderate numbers were seen from December to April.

Among the non-copepod zooplankton, _Cladocerans_ and _Euphausids_ (mainly consisting of Calyptopis and Furcitia larva stages of _N. australis_) dominated in almost all months. A composition between 28% and 75% of _Cladocerans_ was observed from August to November and dropped to a lower composition from

December to February, but they were absent in January. The composition increased again in March and reached the maximum of 83% in May, however, only a very low percentage was observed in July. Euphausids were present in all months although a moderately high composition between 23% and 71% was found in August, September and December only. During the remaining months only a low proportion was found. A sharp decline in composition in October and November was probably due to the influence of the River Derwent freshwater runoff. A moderate proportion was observed again in June and July.

Molluscs, which consisted of mainly Gastropods dominated the whole zooplankton population in January and February with a high percentage of 61% and 97% respectively. A lower percentage composition was observed in April and May, however, during the remaining months only a very low proportion was observed when they occurred.

Lucifer hanseni was present in all months except December, dominating the non-copepod zooplankton population in June and July with the composition of 55.3% and 46.0% respectively. A lower proportion was observed in March and during the remaining months only a small proportion was found when it occurred.

Fish eggs and larvae were represented, comprising between 20% and 40% in the non-copepod zooplankton population during November, December and February. Only a small proportion was found during the remaining months except April. Amphipods dominated the non-copepod population, comprising 64% in March, however, during the remaining months only a very low proportion was observed when they occurred. Decapod larvae were represented, with a maximum composition of 10.6% among the non-copepod zooplankton population in July but usually only a low proportion was observed when they occurred. Appendicularians dominated the October non-copepod zooplankton population with the composition of 33%. Only a low proportion of between 2% and 5.5% was found in April, May and July, however, a very low composition was found during the remaining months when they occurred.

The zooplankton which are listed as "Other groups" consisted of the following:-

Coelenterates; Ctenophores; Chaetognaths; Ostracods; Cumacea; Isopods; Mysis; Echinoderm larvae and Annelid worms.

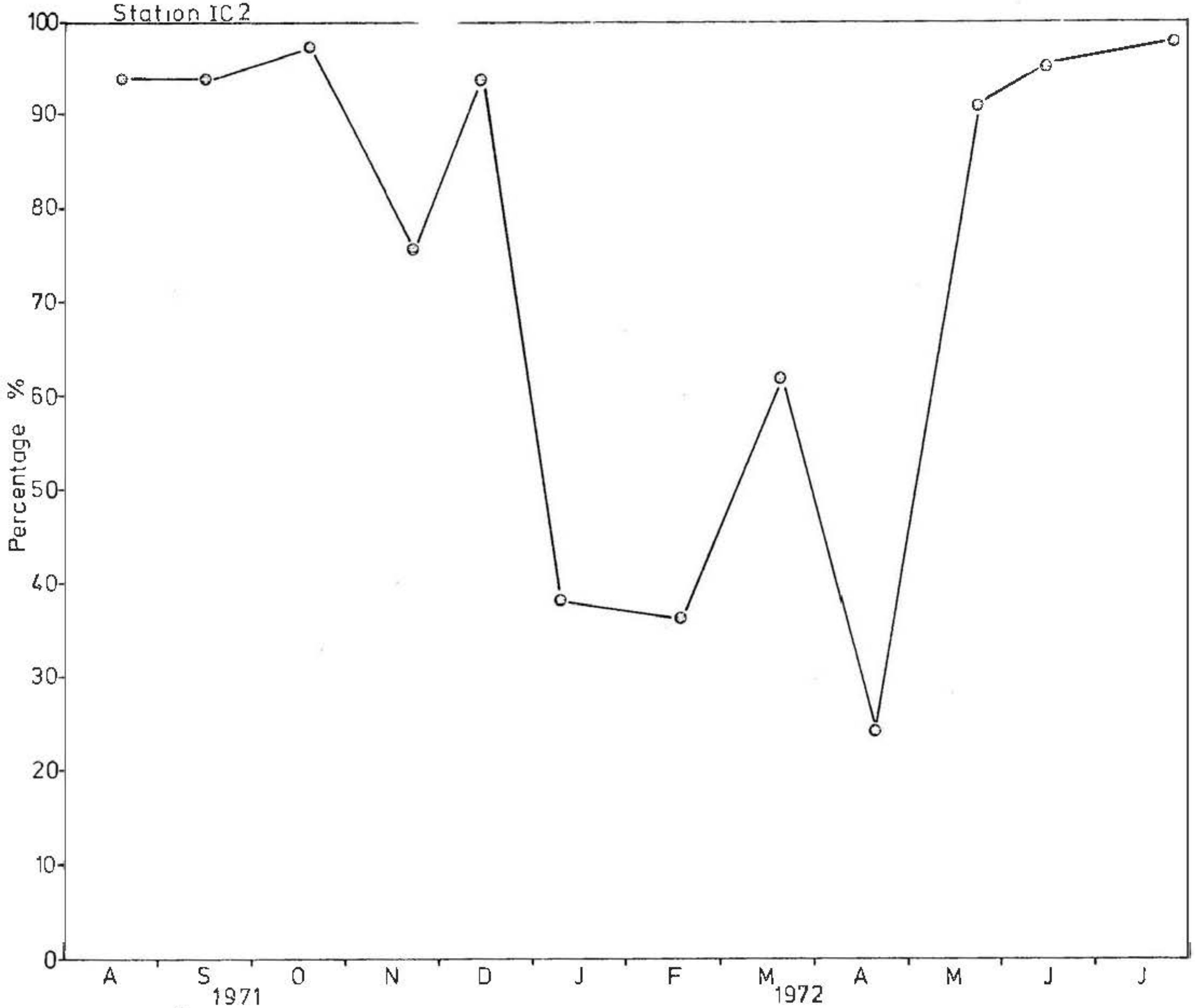

Fig. 16 Copepod as a percentage of the total zooplankton

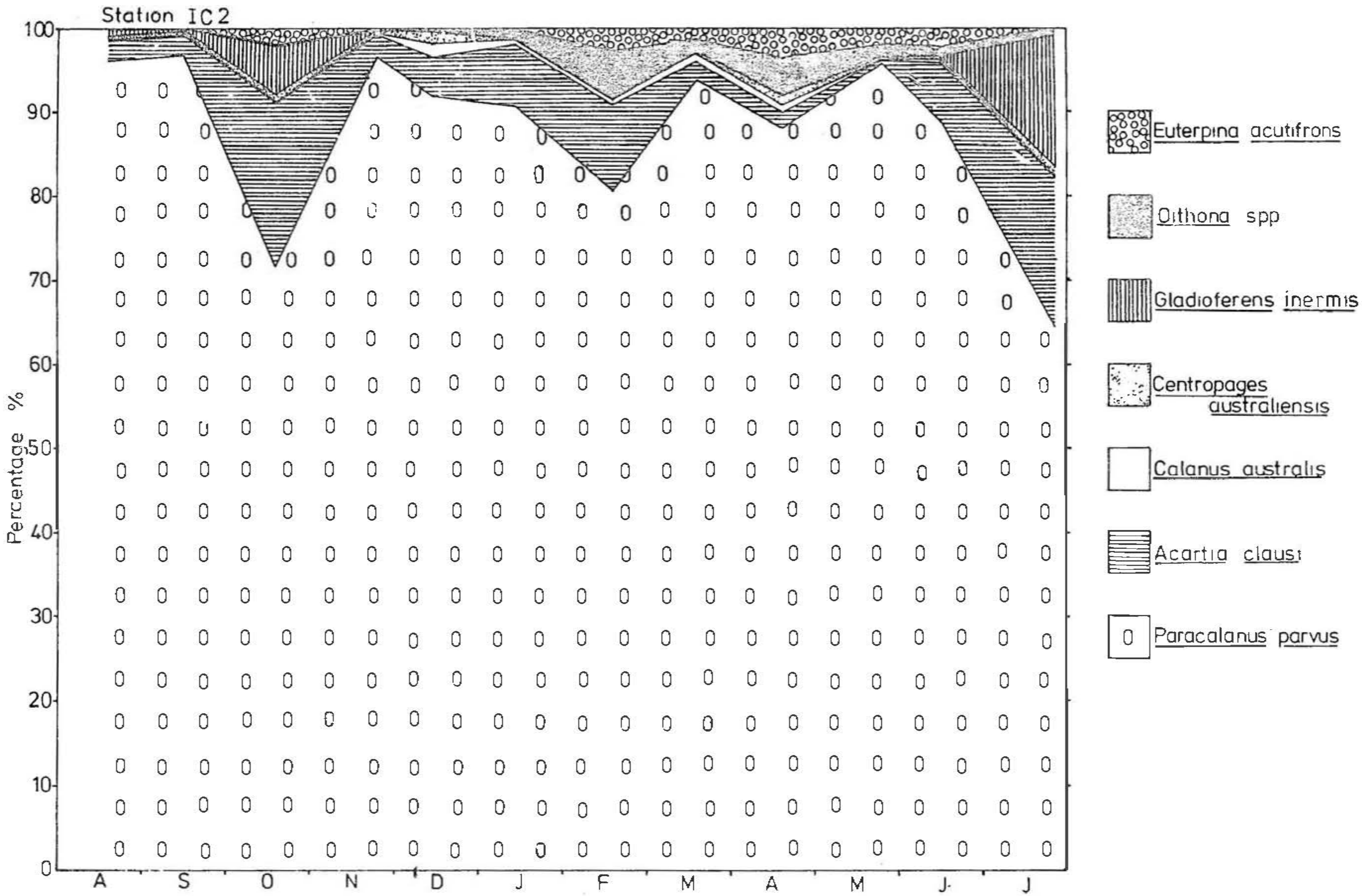

Fig 17 Percentage composition of common copepod

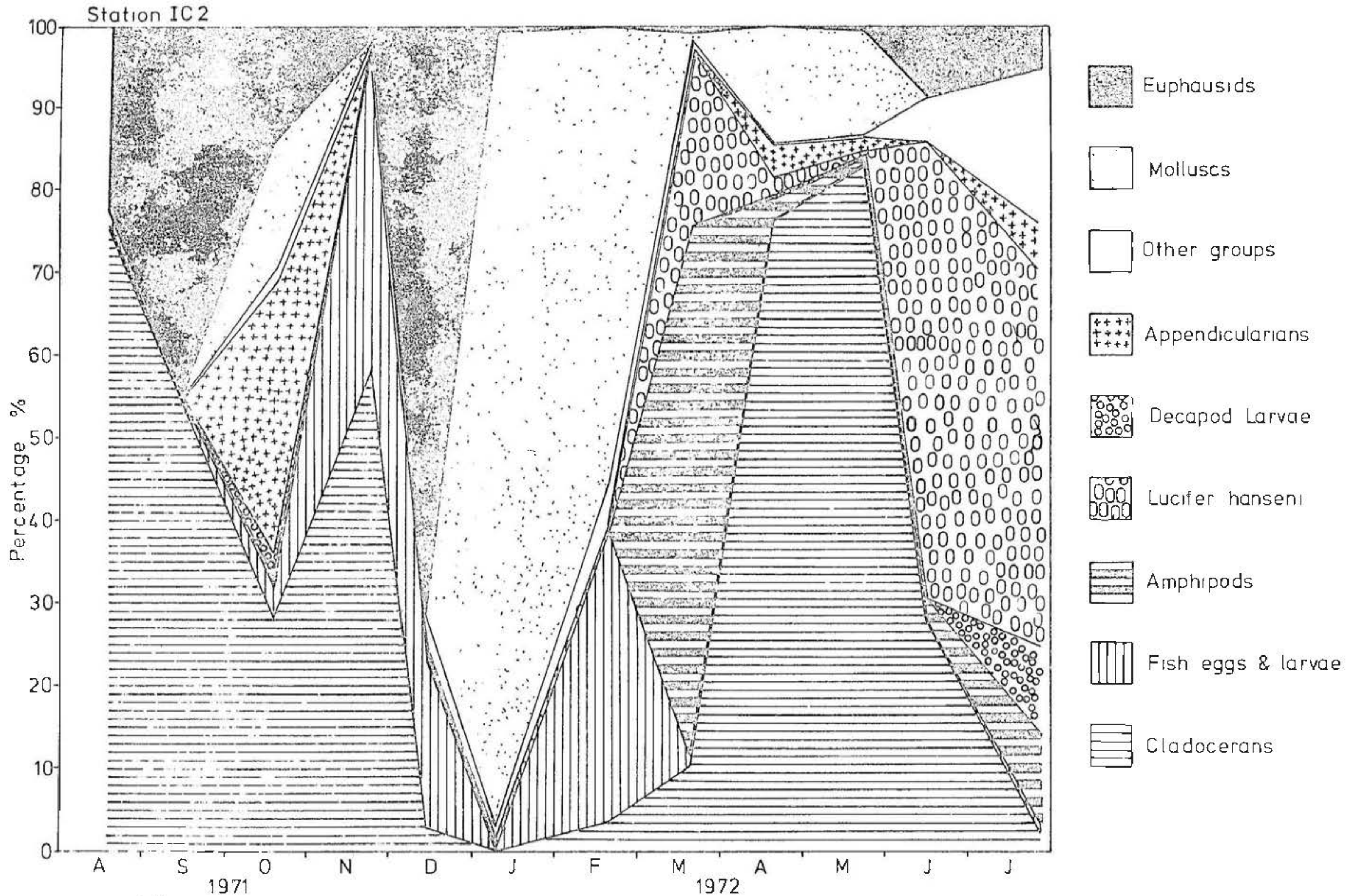

Fig 18 Percentage composition of non-copepod zooplankton

RELATIVE COMPOSITION OF ZOOPLANKTON GROUPS AS AN INDICATION OF WATER MOVEMENT IN THE INSHORE COASTAL WATERS OF SOUTH-EAST TASMANIA

INTRODUCTION

The presence of species of oceanic copepods in coastal waters has been used as an indicator of the intrusion of oceanic waters into coastal areas at George Bank, Gulf of Maine (Colton, Temple and Honey, 1962). Jeffries (1962) showed that the indicator species concept can be also applied to estuarine circulation over a range of as little as a mile or so.

Studies on the seasonal and diurnal vertical variation in occurrence and abundance of zooplankton in inshore coastal waters (Storm Bay, Mouth of the Derwent River and the northern part of D'Entrecasteaux Channel) of south-east Tasmania revealed a large number of individuals of some species of oceanic zooplankters from time to time (see early part of this Section). This suggests an invasion of oceanic waters into the coastal areas. Two other species of zooplankton were found to be restricted to the mouth of the Derwent River and D'Entrecasteaux Channel waters; only on two occasions were they found in Storm Bay, which suggested that Storm Bay is normally coastal, with occasional estuarine influences as well. In this Section an attempt is made to determine such influences by using relative abundances of indicative zooplankton species groups.

MATERIALS AND METHODS

The data used were averages of six day and night zooplankton samples, collected and counted once every month at each of the three Stations, IC1, IC2 and IC3 (see early part of this Section).

The usual method of identifying water masses using specific indicator species (Russell, 1939; Fraser, 1952; Bary, 1959; Shead, 1965; Miller, 1972; and Nyan Taw - see Section II) was not possible due to the complexity of the marine environment. Offshore areas East of Tasmania are influenced by both warm, high salinity Sub-tropical and cold, low salinity Sub-antarctic waters, a result of the Sub-tropical Convergence moving north and south in accordance with season (Wyrtki, 1960). In addition, freshwater runoff from the Derwent River is also seasonal.

Dominant indigenous coastal species such as Paracalanus parvus and Acartia clausi were excluded in order to emphasize the occurrence of the more unusual forms. A few minor oceanic species introduced from offshore waters east of the area, which were found to be able to maintain themselves in the inshore coastal waters such as Mecynocera clausi, Ctenocalanus vanus, Centropages bradyi and Oncaea media were omitted. Species considered were classified according to their previous habitat records, namely -

i) inshore coastal)
ii) coastal) (Table 3)
iii) oceanic)

The pattern of inshore coastal, coastal and oceanic influences implied by these observations was examined in the context of records of freshwater flow from the Derwent River, and seasonal depth profiles of salinity at the Stations.

TABLE 3. Zooplankton Indicator Species Groups

Inshore Coastal species group	Coastal species group	Oceanic species group
* Sagitta guileri Nyan Taw	*Calanus australis Brodsky	*Neocalanus tonsus (Copepodite Stage V)
Pseudodiaptomus cornutus Nicholls	*Centropages australiensis Fairbridge	*Clausocalanus ingens Frost & Fleminger
	Labidocera tasmanica Nyan Taw	*Sagitta serratodentata tasmanica Thomson
		*Sagitta minima Grassi
		*Salpa fusiformis Cuvier
		Mesocalanus tenuicornis Dana
		Calanoides carinatus (Kroyer)
		Calocalanus pavo (Dana)
		Calocalanus styliremis Giesbrecht
		Calocalanus tenuis Farran
		Leptocalanus plumulosus (Claus)
		Clausocalanus arcuicornis (Dana)
		Clausocalanus mastigophorus (Claus)
		Clausocalanus jobei Frost & Fleminger
		Clausocalanus parapergens Frost & Fleminger
		Euchirella rostrata (Claus)
		Metridia lucens Giesbrecht
		Pleuromamma abdominalis (Lubbock)
		Pleuromamma gracilis (Claus)
		Lucicutia flavicornis (Claus)
		Candacia bipinnata (Giesbrecht)
		Heterorhabdus papilliger (Claus)
		Scolecithrix danae Lubbock
		Acartia danae Giesbrecht
		Racovitzanus sp.
		Oncaea venusta Phillippi

* Major contributors in the group.

RESULTS AND DISCUSSION

In general, Stations IC1 and IC2 can be considered as having a similar fauna, differing considerably from that at Station IC3, as is shown by the proportions of inshore species at the three Stations throughout most of the year. The presence of this group at Station IC3 in September and November was associated with a high freshwater flow from the Derwent River, recorded by a recording Station upstream at Macquarie Plains, from August to November (Fig. 3). A pronounced stratification of the water column, with low-salinity surface water observed from September to December at Stations IC1 and IC2 and in November;and December at Station IC3 (Fig. 2), is consistent with the view that, at times of high-volume river flow, freshwater from the Derwent has a seasonal influence on the environment in Storm Bay.

Oceanic influence also was noted at Station IC3 in August, as indicated by the presence of 90.3% of oceanic species in the plankton. Substantial influence of oceanic waters was detected again in December, the proportion of oceanic species finally reaching 97.0% in January. At Station IC2 substantial oceanic water influence (22.9% of oceanic species) was first encountered in December, reaching a maximum of 93.4% of oceanic species in February and extending at the time into Station IC1 area (95.1% of oceanic species). Sub-surface high salinities at Stations IC2 and IC3 in December were further evidence of oceanic influence (Fig. 2). From March to June, waters at Station IC3 were coastal in nature, with only 1.5-15.9% of oceanic species and no inshore coastal species being found. In July, 59.5% of oceanic species was recorded at Station IC3, indicating a return of oceanic waters, while Stations IC1 and IC2 yielded low or negligible percentages of oceanic species during this month, probably due to the high freshwater runoff in the Derwent (Fig. 19). The appearance of oceanic influences at Station IC3 in July as indicated by oceanic species was in agreement with the subsurface high salinities recorded at the Station during the month (Fig. 2).

The distribution of water masses off the East coast of Tasmania, using zooplankton as indicators has been studied and identified (see Section II), and confirmed Wyrtki's (1960) findings. The study period on the East coast was from August, 1971 to May, 1973, which was within the period of the present investigation of the inshore coastal waters.

The strong oceanic influence at Stations IC1 - IC3 from December to February was recognized by the oceanic species _Neocalanus tonsus_, _Sagitta serratodentata tasmanica_ and _Salpa fusiformis_. These species have been found in the East coast of Tasmania waters, where _N. tonsus_ and _S. fusiformis_ were found to have affinities to Sub-antarctic and Sub-tropical waters respectively, whereas _S. serratodentata tasmanica_ was considered as a local oceanic indicator species (see Section II).

N. tonsus was taken at the Storm Bay Stations from August to January, large numbers being found in December and January. Similar occurrences of this species (both adults and Stage V copedites) was observed off the East coast (taken in August, November and December Cruises), which suggests, as in the waters off the East coast, that the inshore waters were influenced by Sub-antarctic waters. The East coast of Tasmania most probably had Sub-antarctic water influences from August to December (see Section II).

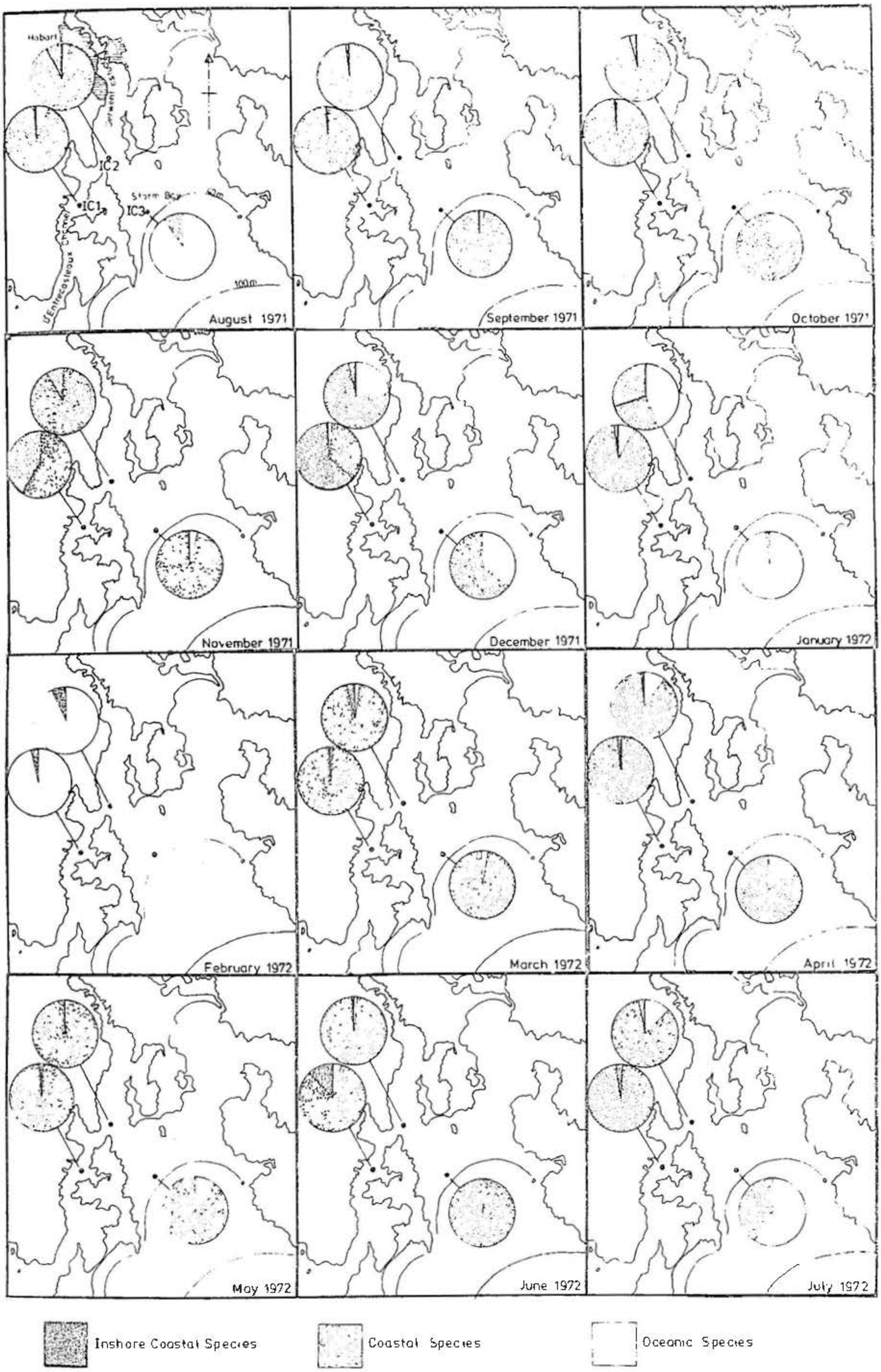

Fig. 19

Seasonal composition of zooplankton species groups at stations IC1, IC2 & IC3.

A major change of oceanic water influences in Storm Bay was found in February, when N. tonsus disappeared and was replaced by S. fusiformis which dominated the plankton sample. S. fusiformis was found in March and April Cruises off the East coast, where it indicated the Sub-tropical waters. The high number of this species is evidence that the strong oceanic influence in the inshore waters was due to the extension of the Sub-tropical waters from East of the study area.

From March onwards, although the oceanic influence was low, except in July at Station IC3, the presence of oceanic species such as Salpa fusiformis, Leptocalanus plumulosus, Pleuromamma abdominalis and Pleuromamma gracilis, which have affinities to Sub-tropical waters, suggested that the area was influenced by such oceanic waters.

According to figures released by the Department of the Environment, in reports to the Tasmanian Parliament in 1972 and 1973, there were high levels of heavy metals in the Derwent River waters. Abnormally high concentration of heavy metals (zinc, cadmium and copper), which would be lethal to human consumption, were found in oysters from Ralph's Bay and from Pipe Clay Lagoon, Frederick Henry Bay (Thrower and Eustace, 1973a, 1973b). Eustace (1974) found that shellfish from the Derwent River have the ability to accumulate certain metals to abnormally high levels, but that this was not the case with finfishes. The source of these heavy-metal concentrations in molluscs found in the Derwent River and adjacent waters would be industrial waste discharge and domestic sewage. The accumulation of heavy metals in the Derwent River waters and their distribution outside the estuary would depend on tidal movements and current flows (oceanic and coastal currents as well as freshwater flow).

The evidence both of indicative zooplankton species groups and the salinity profile indicates that the study area, although normally inshore coastal and coastal in nature, was occasionally influenced by both estuarine and oceanic waters. The oceanic water masses involved Sub-tropical waters from the north and Sub-antarctic waters from the south. Thus, when an influx of these oceanic waters occurs, it may affect the outflow of the Derwent in two possible ways. If the flow is counter-clockwise, it may wash the Derwent waters down the Channel, or, if clockwise, into adjacent bays. The influence of known heavy-metal pollution may not be confined to the Derwent itself.

GENERAL DISCUSSION

In terms of geographical structure of the area and the position of Stations, the present study can be compared with the work by Jillett (1971) who operated two Stations for a period of 21 months at Waitemata Harbour and 14 months at Jellicoe Channel at Hauraki Gulf, New Zealand, where the offshore region is of Sub-tropical nature. Waitemata Harbour Station is situated in a similar region to that of Stations IC1 and IC2, whereas the region occupied at Jellicoe Channel is comparable with Station IC3 in the present study.

The zooplankton species mainly the coastal and common occurring oceanic species between the two areas, are comparable (Table 4). The only difference is that the present area is under the influence of both Sub-tropical and Sub-antarctic waters.

Jillett found that oceanic species were never numerous and that the occurrence was restricted to a certain period of time at Waitemata Harbour, but at Jellicoe Channel Station a number of oceanic components were taken in every sample and that a few of these were abundant at times. He noted that in late Summer and Autumn the plankton composition changed almost completely from predominantly neritic to predominantly oceanic and that this change coincided with the subsurface intrusion of oceanic water into the outer Gulf area. A similar pattern in terms of species composition and hydrology as has been given by Jillett, was observed in the present study. However, a more objective approach was adopted here using relative abundance of indicative zooplankton species groups to determine the influence of oceanic water influences.

TABLE 4.

South-east Inshore Coastal Waters	Hauraki Gulf, New Zealand. (Jillett, 1971)
Inshore coastal and Coastal	
Calanus australis	*Calanus australis*
Paracalanus parvus	*Paracalanus parvus*
Centropages australiensis	*Centropages aucklandicus*
Gladioferens inermis	*Temora turbinata*
Pseudodiaptomus cornutus	*Labidocera cervi*
Labidocera tasmanica	*Acartia clausi*
Acartia clausi	*Corycaeus aucklandicus*
Euterpina acutifrons	*Euterpina acutifrons*
Nyctiphanes australis	*Nyctiphanes australis*
Sagitta guileri	
Oceanic	
Neocalanus tonsus	*Mecynocera clausi*
Mecynocera clausi	*Clausocalanus arcuicornis*
Clausocalanus ingens	*Ctenocalanus vanus*
Ctenocalanus vanus	*Oncaea media*
Centropages bradyi	*Sagitta serratodentata*
Oncaea media	
Sagitta serratodentata tasmanica	
Sagitta minima	

It is evident that the study area has the influences of estuarine, coastal and oceanic waters. Moreover, oceanic waters involved warm, high salinity Sub-tropical and cold, low salinity Sub-antarctic water masses. The narrowness of the continental shelf on the East coast of Tasmania (East of the study area) additionally made the area more vulnerable to such oceanic influences. These water masses which oscillate seasonally along the East coast and the seasonal high freshwater flow from the Derwent River Estuary, are no doubt the main factors reflecting the seasonal cycles of zooplankton composition as well as biomass in the area.

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SECTION IV

ZOOPLANKTON AND HYDROLOGY OF DERWENT RIVER ESTUARY

INTRODUCTION

Since Ong's work of 1967 on the spatial and temporal distribution of zooplankton of the surface waters of the Derwent Estuary, a number of studies on the ecology of Australian estuaries have been published (Hodgkin and Rippingale 1971; Arnott and Hussainy 1972; Rippingale and Hodgkin 1974; Neale and Bayly 1974). The zooplankton and hydrology of the coastal waters off the Tasmanian East Coast as well as inshore waters of south-eastern Tasmania have also been investigated (see Sections II and III and also Nyan Taw 1975b).

During the studies on the inshore coastal waters two new species (Nyan Taw 1974, 1975a) and a number of species which have not been recorded and which are of importance to the zooplankton communities, were revealed.

Nyan Taw (1975b) found that the inshore coastal areas (Storm Bay, mouth of the River Derwent and the northern part of D'Entrecasteaux Channel) show strong influences of both oceanic and estuarine waters. Off the East Coast of Tasmania the water masses found were identified using the indicator species concept, which revealed the presence of both Sub-tropical and Sub-antarctic waters (see Section II). Fortunately, since both studies were made during the same period, these can be correlated. However, although Ong's work is of great help, direct correlation to his studies was not possible due to new species and additional records of estuarine and inshore coastal zooplankton species in the area. The present investigation is an extension of the previous studies so as to have a better knowledge for the area as a whole.

MATERIALS AND METHODS

Field Procedure

Zooplankton

Zooplankton samples were collected by oblique tows of approximately 2 minutes duration with a standard WP-2 net (mesh size 200μm, mouth opening 0.25m^2), fitted with a flow metre of the type Tsurumi-Seiki-Kosakusho. The net was attached to a wire depressor. The samples were collected from the Zoology Department Research Vessel "Neotrigonia" and preserved in approximately 5% formalin immediately after each collection.

Two cruises were made, one on 1st. October, 1973, and the other on 23rd. April, 1974, when 10 stations were operated for each cruise. These months were selected to cover wet (high freshwater flow) and dry (low freshwater flow) periods in the river. The extreme upstream station was just below New Norfolk Jetty and the furthest downstream station was at the mouth of the river (off Pierson's Point). The length of the river covered was approximately 50 kilometres. The location of the stations is shown in Figure 1.

Hydrology

Water samples for salinity determination and temperature were collected immediately after zooplankton sampling. The methods used were the same as in Section III.

Laboratory Procedure

Zooplankton

The same methods and procedure were used in sub-sampling and counting of zooplankton as in Section II.

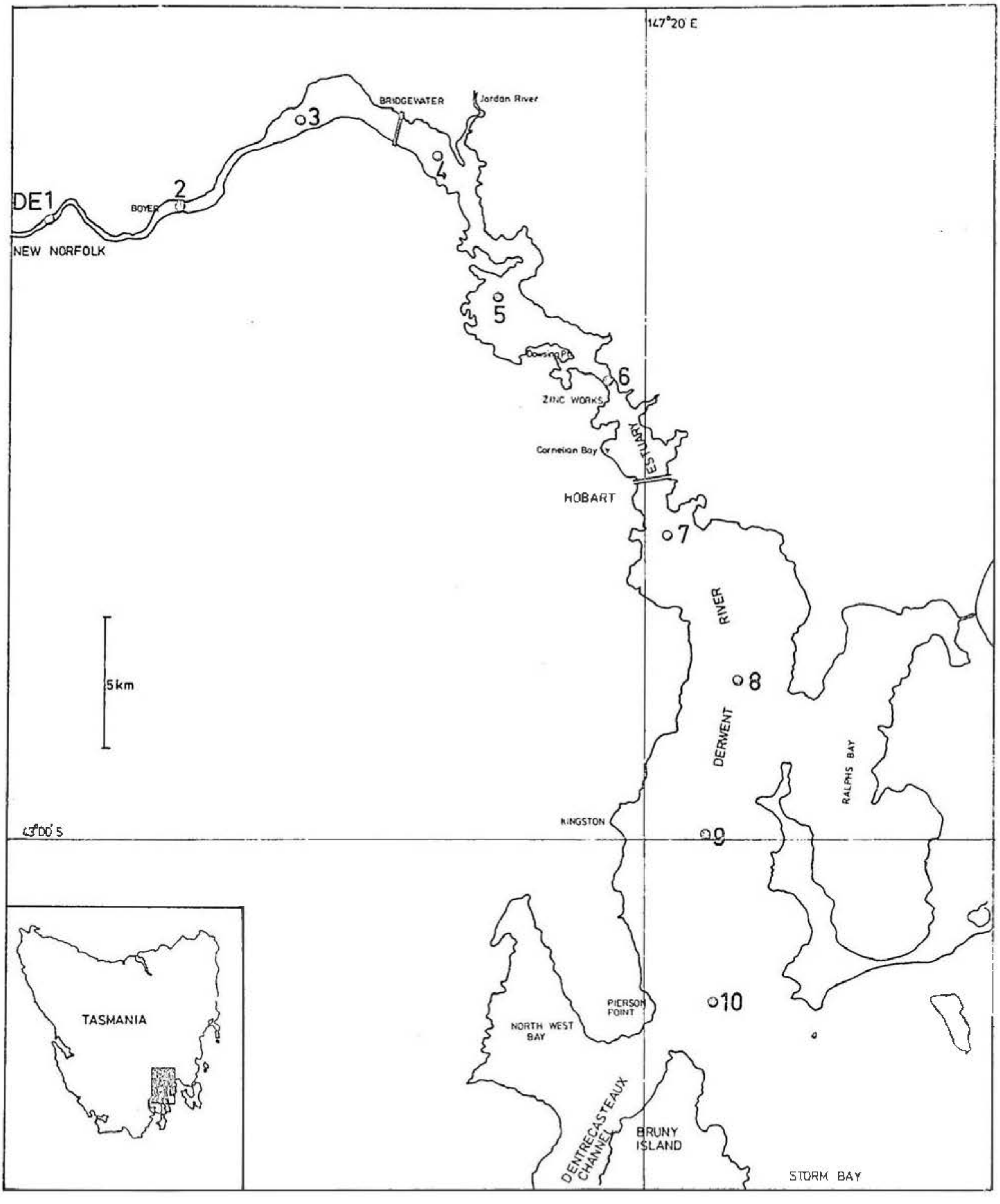

Fig. 1 – Derwent River Estuary showing position of the stations

Hydrology

The Inductive Salinometer was used to determine the salinity for all the samples collected during both cruises. The apparatus was calibrated before each batch of determinations using Copenhagen standard sea water.

THE ENVIRONMENT

Salinity and Temperature

Spatial depth profile of salinity and temperature for both cruises (October and April) is shown in Figure 2.

Salinity distribution for both Cruises was very similar except that the estuarine system was further downstream during Cruise I than Cruise II. This was probably due to the higher freshwater discharge recorded prior to Cruise I than Cruise II (average flow of 15 days prior to Cruise I - 6374 cusecs; Cruise II - 1915 cusecs).

Temperature profile follows a similar pattern to that of salinity, but with much less variations during both Cruises.

To aid in the discussion zonation of the river given by Guiler(1955) is used(see discussion).

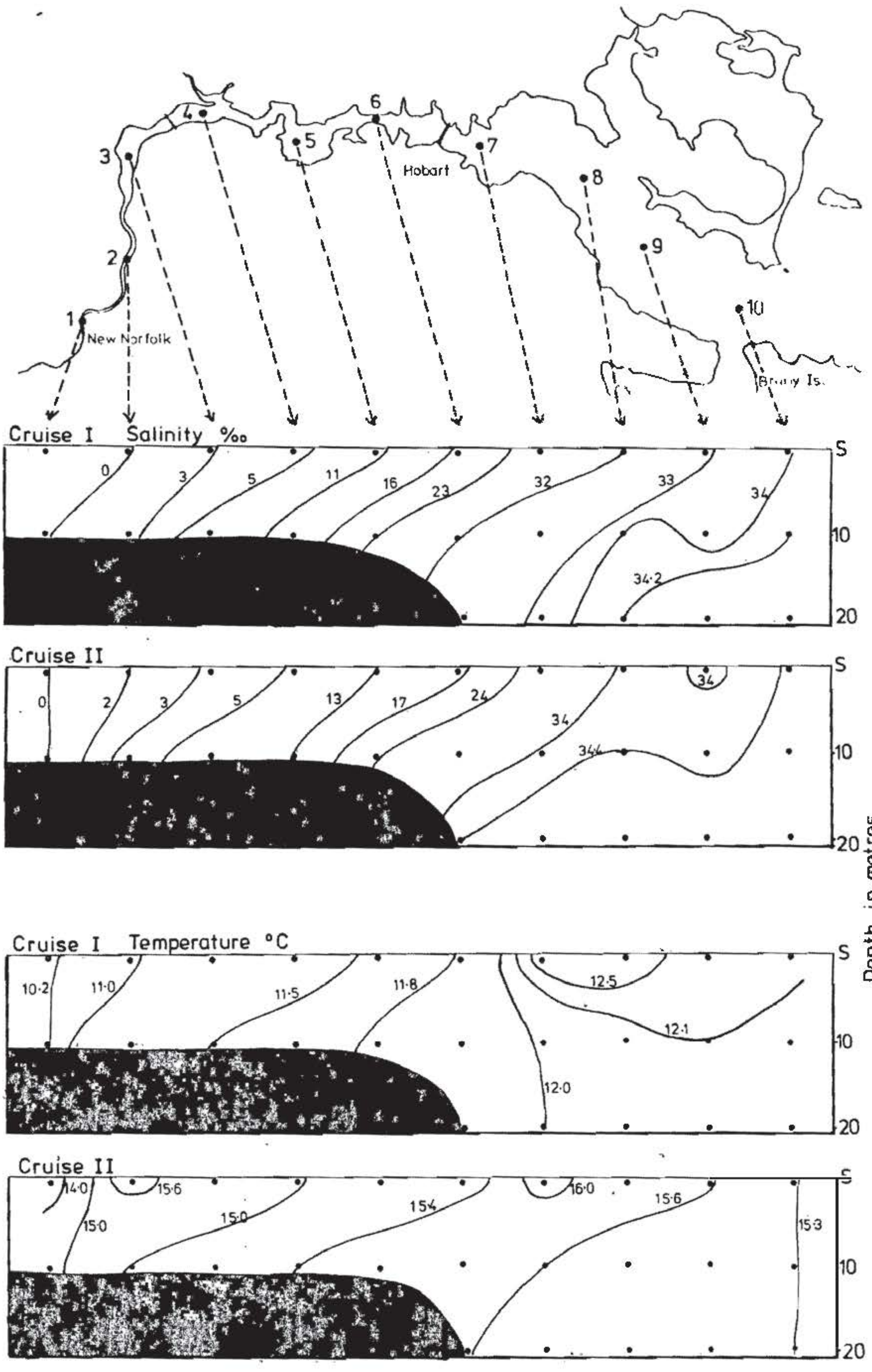

Fig 2 Depth profile of salinity and temperature of Derwent Estuary during Cruise I (October 1973) and Cruise II (April 1974).

SPATIAL DISTRIBUTION AND ABUNDANCE OF THE ZOOPLANKTON

The spatial distribution and abundance of the zooplankton for Cruises I and II is given in Figures 3 and 4. The salinities of the area covered in the Derwent Estuary ranged from 0‰ to 34.5‰, so that the species taken were representatives of the freshwater, estuarine and marine environment. A few of the marine species were of oceanic origin.

The cyclopoid *Mesocyclops leuckarti* Claus and the calanoid *Boekella triarticulata* (Thomson) were found in small numbers (less than $5/m^3$) in the upper region of the river where the salinities were nil. Both species were present in samples at Stations 1 and 2 during Cruise I, but only *B. triarticulata* was taken at Station 1 in Cruise II. Both species are confined to the freshwater zone in the River Derwent system.

Estuarine species consisted of *Gladioferens spinosus* Henry, *Gladioferens pectinatus* (Brady) and *Sulcanus conflictus* Nicholls. Of these species *G. spinosus* occurred in small numbers of less than $5/m^3$, although present in both cruises. During Cruise I it was taken at only two Stations - Stations 2 and 3. However, it was encountered further downstream as far as Station 6 during Cruise II where surface salinity was 16.98‰ . Since it was found together with *B. triarticulata* and being found in slightly higher numbers in reduced salinity waters during Cruise I, this suggests that it inhabits the freshwater portion of the estuary.

G. pectinatus was the most abundant estuarine species, dominating the plankton samples. It was present from Stations 2 to 10 and from Stations 2 to 9 during Cruises I and II

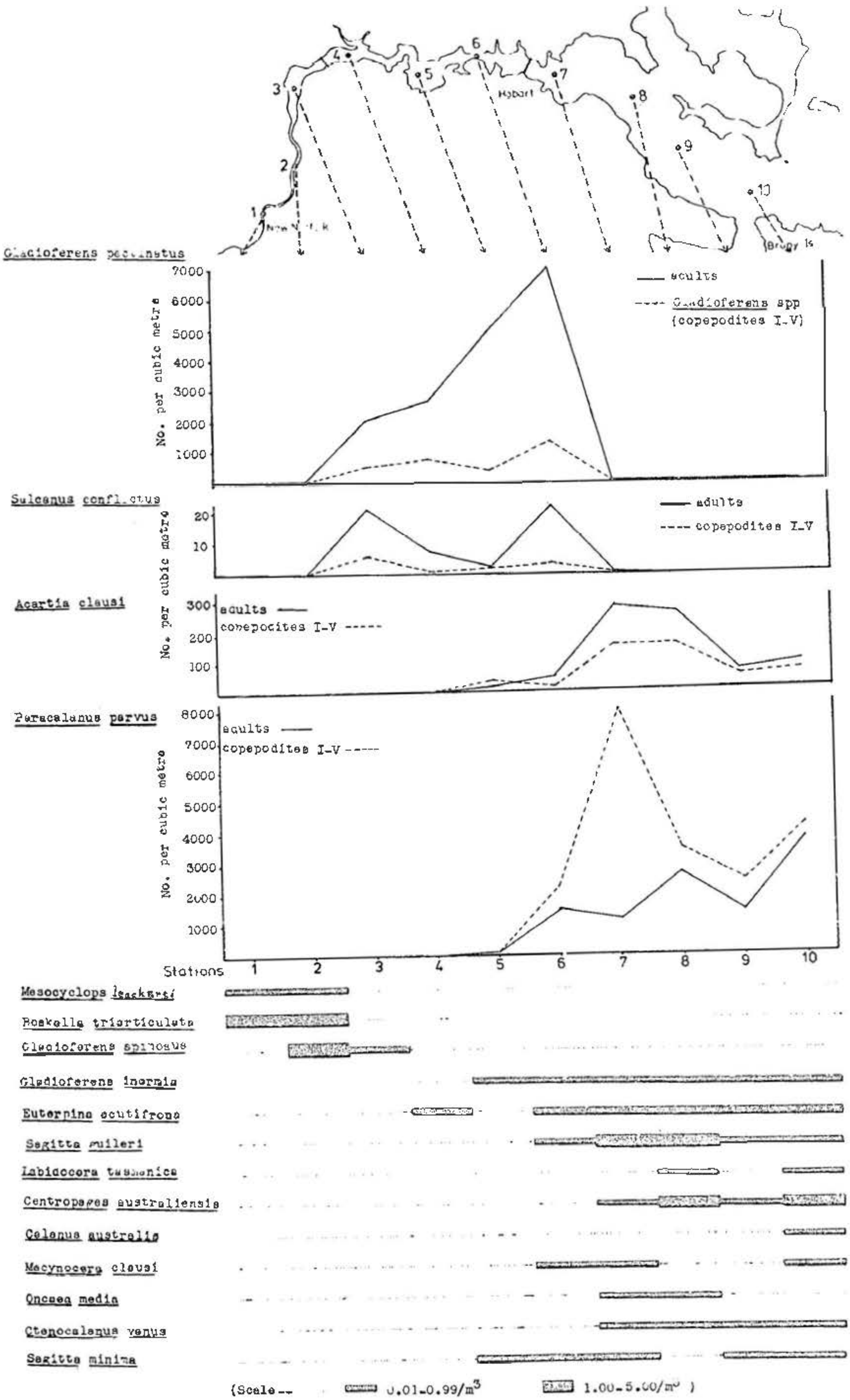

Fig. 3 Spatial distribution and abundance of the zooplankton in the Derwent Estuary during Cruise I (October 1973).

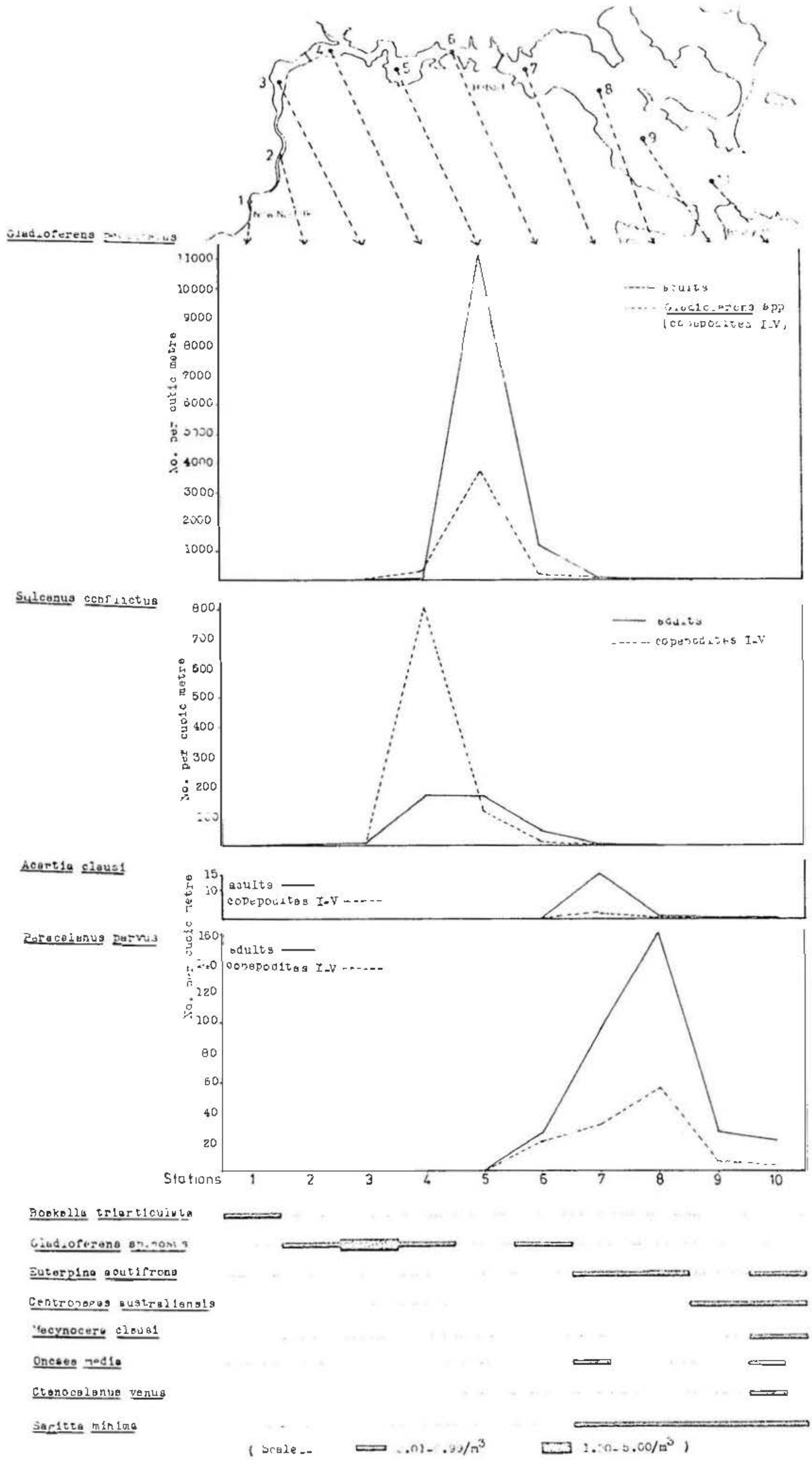

Fig.4 Spatial distribution and abundance of the zooplankton in the Derwent Estuary during Cruise II (April 1974).

respectively. The salinities in the marine zone (Stations 7-10) were as high as 34.5‰. The presence of this species in a typical marine environment was noted by Bayly (1965), Jillett (1971) and Arnott and Hussainy (1972). However, the number found in the marine zone especially at Stations 9 and 10 was very low (less than $0.5/m^3$). A slightly higher number was taken in the marine zone nearer to the tidal zone, where the species could have washed down from the estuarine gradient zone. Copepodite Stages I to V of a Gladioferens spp. were found in both Cruises in the same zone as G. pectinatus, although in lesser numbers. These copepodites I - V were most probably the copepodites of G. pectinatus, this species being found in large numbers from Stations 3 to 6 during Cruise I and at Stations 5 and 6 during Cruise II. Figure 5, showing the percentage spatial distribution of combined adults and copepodites I - V suggests that it preferred the marine part of gradient zone.

Sulcanus conflictus was next to G. pectinatus in in abundance amongst the estuarine species. It was found during both Cruises, but lesser in number during Cruise I (less than $25/m^3$). During Cruise I it was taken from Stations 3 to 7, where adults were found in larger numbers. At Station 7 only a few specimens ($0.27/m^3$) were taken, which were probably washed down from the tidal zone. It occurred in a wider range, from Stations 2 to 8 during Cruise II. The numbers encountered were high, a maximum of $166.1/m^3$ for adults at Station 4 and $807.6/m^3$ for copepodites I - V were recorded. In the remaining stations downstream the number of adults taken was higher than the copepodites I - V. Although it occurred from Station 2 where the surface salinity was 2.29‰ to Station 8 where the

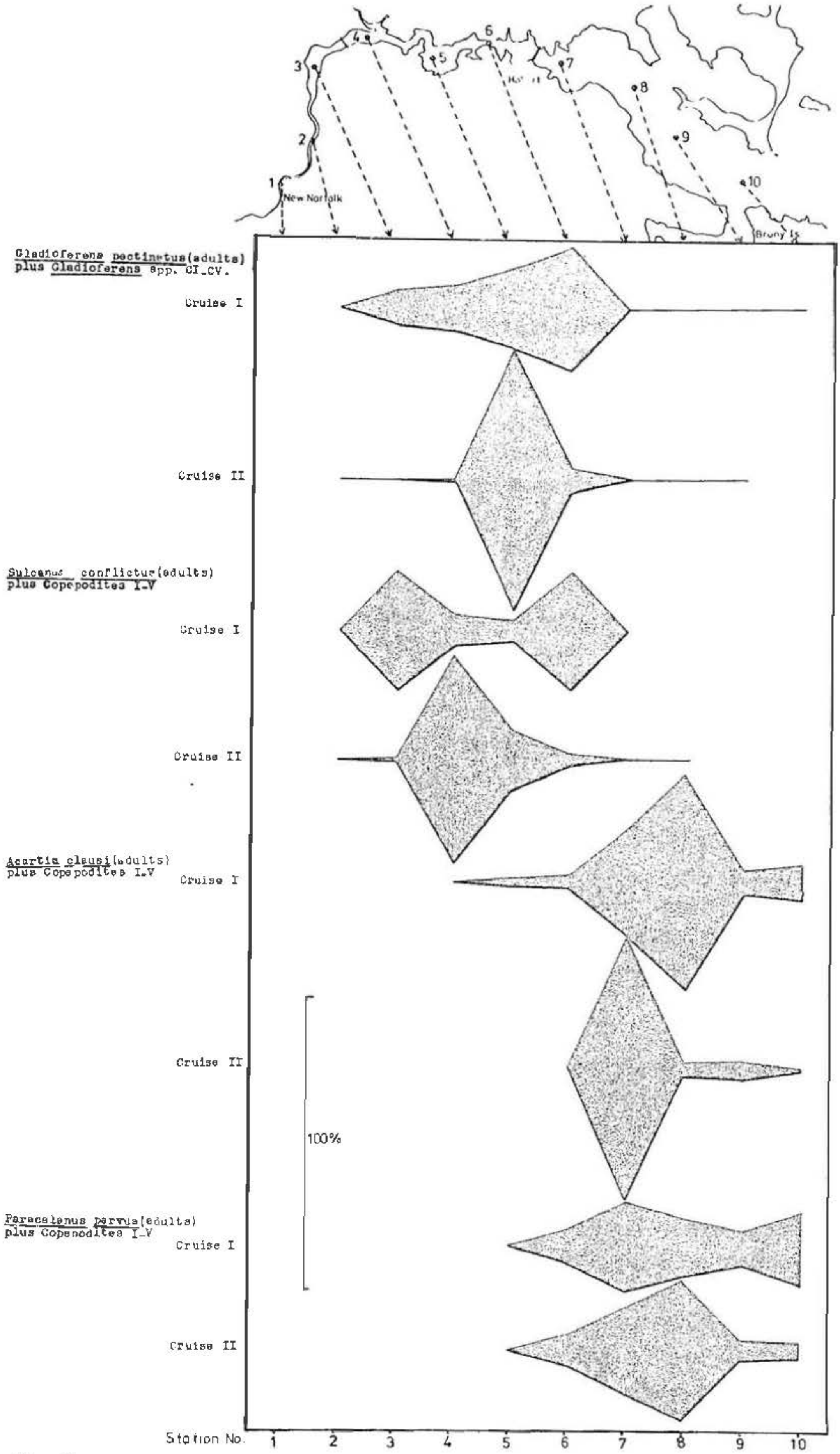

Fig. 5 – Spatial distribution of the major copepods during Cruises I and II (October and April). At each of the stations sampled the quantity of the copepoda is expressed as a percentage of the total occurrence.

surface salinity was as high as 34.31‰, the main high concentration was between Stations 4 to 6. At the two extreme stations (Stations 2 and 8) the number taken was very low (less than $0.5/m^3$). Percentage spatial distribution for combined adults and copepodites I - V is given in Figure Unlike G. pectinatus the distribution during Cruise II suggested the species to have preference to the freshwater part of gradient zone.

In the marine zone two calanoid copepod species - Paracalanus parvus (Claus) and Acartia clausi Giesbrecht dominated the zooplankton population. The remaining species occurred in low numbers of less than $5/m^3$. Four species - the calanoid copepods Mecynocera clausi Thompson and Ctenocalanus vanus Giesbrecht; the cyclopoid copepod Oncaea media Giesbrecht; and the Chaetognath Sagitta minima Grassi, all of oceanic water origin, were also taken. The inshore coastal and coastal species found were the calanoid copepods Gladioferens inermis Nicholls, Labidocera tasmanica Nyan Taw, Centropages australiensis Fairbridge and Calanus australis Brodsky; the pelagic Harpacticoid Euterpina acutifrons (Dana); and the Chaetognath Sagitta guileri Nyan Taw.

Paracalanus parvus dominated the zooplankton population in the marine zone during both Cruises. The number taken was lesser during Cruise II, where the maximum of $215.3/m^3$ (adults and copepodites I - V) was found whereas $9170.9/m^3$ was recorded during Cruise I. It was present as far up the river as Station 5 during Cruise I and Station 6 during Cruise II. The presence of this species in the area of Stations 5 and 6 where the surface salinities were as low as 11.03‰ and 16.98‰

respectively, was probably due to the tidal currents. During Cruise I, the number of adults generally increased downstream reaching a maximum at the furthest marine zone (Station 10), however, the copepodites I - V appeared to prefer the area near the tidal region (around Station 7). The number of copepodites I - V found was larger at all Stations than the adults during this Cruise. In Cruise II the adults dominated the population at all Stations. Both adults and copepodites I - V were found to be concentrated in Stations 7 and 8 areas. During this Cruise the adults dominated the species population. Percentage spatial distribution is shown in figure 5 for combined adults and copepodites I - V. Generally, it showed that the species was almost evenly distributed in the marine zone during Cruise II, most probably due to the high flow of freshwater from the Derwent. However, in Cruise II the maximum concentration was at Stations 7 and 8, which could be accounted for by the low freshwater flow combined with the high coastal and pronounced oceanic influence from December to February and from January to June, combined with the high influence of open coastal water (Nyan Taw, 1975b and also see Section III).

Acartia clausi was the second most abundant species in the marine zone. Substantial numbers ($\leqslant 300/m^3$) were taken during Cruise I, but the number found during Cruise II was low ($\leqslant 15/m^3$). It penetrated as far as Station 5 during Cruise I. In Cruise II it was present as far as the area of Station 6 only. Copepodites I - V were found in lesser numbers than the adults during both Cruises. The spatial distributional pattern of this species (Figure 5) was similar to that of P. parvus. The main difference is that the maximum concentration was found during both Cruises at Stations 7 and 8.

The remaining marine species consisted of species typical of inshore coastal, coastal or oceanic water origin.

Of the inshore coastal species, Enterpina acutifrons appeared to be able to tolerate considerably diluted estuarine waters to as far up stream as Station 4 where the surface salinity was 5.43‰ (bottom salinity was 12.4‰) during Cruise I. It was followed in tolerance to diluted estuarine water by Gladioferens inermis which was taken as far upstream as Station 5 during the Cruise when the surface salinity was 11.03‰ (bottom salinity - 23.18‰). Of the two species, only E. acutifrons was found again during Cruise II, being encountered as far as Station 7 upstream.

The sole Chaetognath species Sagitta guileri was found only during Cruise I from Station 6 downstream. A slightly higher number was observed at Stations 7 and 8, the numbers being $3.98/m^3$ and $3.81/m^3$ at Stations 7 and 8, respectiverly, but less than $1/m^3$ in the remaining Stations where found.

The coastal species Centropages australiensis was taken as far as Station 7 during Cruise I. In Cruise II it was present only at Stations 9 and 10. The remaining coastal species Calanus australis which is more typical of open coastal waters was captured only once at Station 10 during Cruise I.

All species of oceanic water origin occurred in both Cruises. Of these species the Chaetognath Sagitta minima seemed to be able to tolerate much reduced salinity, being taken as far upstream as Station 5 where surface salinity was 11.03‰ (bottom salinity - 23.18‰) during Cruise I. It was found again from Station 7 seawards in Cruise II. The next tolerant oceanic species appeared to be *Mecynocera clausi* which was taken as far as Station 5 during Cruise I. The remaining two oceanic species *Ctenocalanus vanus* and *Oncaea media* were present sporadically in the marine zone during both Cruises.

DISCUSSION

Comparison with Previous and Similar Works.

Guiler (1955) studied the hydrology of the Derwent River and the zonation of the river was given using the nomenclature proposed by Rochford (1951). Although, there have been some changes on the structure of the river by the replacement of the old Hobart pontoon bridge by the new Tasman Bridge in 1965, the present hydrological evidence suggested, at least from the hydrological aspect, that the changes are minor. Guiler found the freshwater zone to fall upstream from Boyer, the region above Dowsing Point forms the gradient zone, the region below Dowsing Point as far as Cornelian Bay is a tidal zone while below this area is the marine zone. He stressed that the salinity gradient at any one Station may vary considerably, depending on the flow of freshwater. In the present study, the zonation of the estuarine system derived from the salinity gradient profile following Rochford's nomenclature, is almost the same as that of Guiler's. As such, generally, Stations 1 and 2 can be considered as the Freshwater zone, Stations 3 to 5 fall into gradient zone, the region occupied by Station 6 is the tidal zone, and from Station 7 downstream, can be regarded as marine. This zonation was later evident by the zooplankton population (see later discussion). Ong (1967) based his studies on the surface water zooplankton and salinities of the Derwent postulated that there was a considerable change since Guiler's work and that the zones have shifted upwards.

The spatial and temporal distribution of the zooplankton of the Derwent River Estuary has been studied by Ong (1967). Of the 17 species recorded from the zooplankton groups (Copepoda and Chaetognatha) studied here, 7 species also were recorded by Ong. Ong referred to copepodites of *Acartia clausi* as a dominant species of the marine zone. These specimens should have assigned to *Paracalanus parvus* (see description and discussion in Section I and Section III).

Two species of the genus *Gladioferens* in addition to *G. pectinatus* recorded by Ong were found in the present study. *Gladioferens spinosus* occupies the region from freshwater to the marine part of the gradient zone and *G. inermis* was found from the marine zone to as far upstream as the marine end of the gradient zone.

The sole Chaetognath recorded by Ong and identified as *Sagitta tasmanica* was found as far upstream as off Dragon Point at the marine end of the gradient zone in considerable numbers ($11.7/m^3$). This would be extremely unusual if Ong was referring to *Sagitta serratodentata tasmanica* Thomson, an oceanic species. The only Chaetognath which has been recorded in the Derwent River as far upstream as off the Zinc Works in considerable numbers, was the recently described *Sagitta guileri* Nyan Taw.

Since Ong's study on the River, a number of studies comparable to the present River system were published (Arnott and Hussainy, 1972; Neale and Bayly, 1974). The present findings can be directly comparable to those of the study on the Werribee River by Arnott and Hussainy. Although there seems to be a great difference in the geological structure of the two rivers - the Werribee River is shallow, narrow and a short river which opens into a semi-landlocked Port Phillip Bay, compared with the deep, wide and long Derwent River, which opens into Storm Bay which has open oceanic waters. The region covered along the rivers for both studies is very similar. The regions examined in both rivers were from freshwater to marine.

The lists of species found in the two river systems, especially amongst the freshwater and estuarine species, are almost identical. Both freshwater species, *Mesocyclops leuckarti* and *Boeckella triarticulata* recorded in Werribee River, were also taken in the Derwent River. In the estuarine region, of the three species of genus *Gladioferens* recorded in the Werribee River, two species, *G. spinosus* and *G. pectinatus* were taken in the present study. The absence of the third euryhaline benthic species *G. symmetricus* could probably be due to the depth of the river not allowing the net to scrape the bottom during the plankton tows. It was recorded from the North West Bay river estuary (see Section I).

The four major species *Sulcanus conflictus*, *Gladioferens pectinatus*, *Acartia clausi* and *Paracalanus parvus* recorded in the Derwent River were also found in the Werribee River. However, in the Werribee River *P. parvus* was restricted to the mouth of the river and in addition to the four species another major species *Gippslandia estuarina* Bayly was taken. This species was absent from the Derwent River. *Acartia clausi* was found to be able to penetrate upstream to the region where the salinity was 11.2‰ in the Werribee River, in October, but was restricted to the areas just inside the river in April and September. Similarly, it was taken as far upstream as the marine end of the gradient zone where the surface salinity was 11.03‰ in the Derwent Estuary.

Of the remaining marine species *Pseudodiaptomus cornutus* (not present in the present collection but taken at the mouth of the River during the comparative studies on the inshore coastal waters - see Section III of this thesis) and *G. inermis* were found in both river systems. The only difference between the two rivers in the comparable groups is the absence of *Tortanus barbatus* from the Derwent River and the presence of open coastal and oceanic species in the Derwent Estuary, such as *Calanus australis*, *Centropages australiensis*, *Mecynocera clausi*, *Ctenocalanus vanus*, and *Oncaea media*, suggesting that the marine region of the Derwent Estuary is subjected to a stronger influence of open coastal and oceanic waters than Werribee's marine zone where these species were not recorded.

Zooplankton Distribution and Hydrologically Established Zones.

There have been a number of studies on estuarine zooplankton distribution and their environment (Morris, 1950; Cronin, Daiber and Hulbert, 1962; Bayly, 1965; Ong, 1967; Arnott and Hussainy, 1972; and Neale and Bayly, 1974). However, Rochford (1951, Appendix VIII) discussed the hydrological zones of the Hawkesbury River in relation to the zooplankton distributional results obtained by Morris (1950), which is the only attempt to correlate the hydrological zones with the zooplankton distribution. He found that there is some planktological significance in the hydrological zones in the river.

In the present study it is possible to study such correlation due to the work on the hydrology of the river system by Guiler (1955), which is found to be still applicable by the hydrological evidence resulting from the present survey.

The Stations occupied in the present study have been established in the hydrologically determined freshwater, gradient, tidal and marine zones, the freshwater zone was sampled at Stations 1 and 2, Stations 3 to 5 were in the gradient zone, the tidal zone falls in the region of Station 6, and the remaining Stations 7 to 10 downstream, were marine. The most significant region of the river system both hydrologically, as well as in zooplankton distribution, was the tidal zone. In this zone, as one would normally expect, both estuarine and marine species occur. This feature was clearly seen in the present study. Both major estuarine species - G. pectinatus and S. conflictus and marine species, A. clausi and P. parvus were found in the tidal zone (Figure 5.). Upstream from Station 5 a very low number or none of the marine species were encountered. Similarly, downstream from Station 7 very few or none of the estuarine species were taken. This well defined zooplankton distribution could be attributed to the depth and width of the Derwent and the length of the region covered (about 50 kilometers) in the present study. These findings could most probably be applied to other estuarine systems where only the zooplankton distribution is well known. Such a comparable estuarine system with zooplankton species of known origin would be the Werribee River studied by Arnott and Hussainy (1972). The surface salinities and zooplankton distribution in the Werribee River suggested that the extent of freshwater and marine influence in the river differs from month to month. During October A. clausi was found in the entire length (approximately 10 kilometers) of the region sampled, coinciding with a high surface salinity of 11.7‰ in the Station furthest upstream. The species was restricted to the Station near the mouth of the river in April and September when the surface salinity was approximately 5.0‰ and 0.5‰ , respectively.

Using the definition of tidal zone as the zone occupied by both estuarine and marine species, in October in the Werribee Estuarine system, apart from the two extreme Stations, the region occupied by the remaining Stations was tidal.

The Derwent Estuarine system hydrologically, as well as from the distribution of zooplankton in the river from Ong's study and the present study suggests that apart from periods of major floods, there seem to be just minor shifts in zonation. This was shown by the two Cruises operated in the present study whereby one Cruise was operated during high freshwater flow, the other being during low freshwater flow (see above) when similar distribution of the plankton results were obtained.

<u>Maintenance of Restricted Horizontal Distribution of Zooplankton Population in Estuaries.</u>

The major estuarine species such as <u>Sulcanus conflictus</u> and <u>Gladioferens pectinatus</u> have a restricted distribution in the Derwent estuarine system. Maintenance of such a large population in a restricted manner, resisting the freshwater flow from upstream which tends to wash the population downstream, produces many problems.

The possible factors involving the maintenance of restricted horizontal distribution of plankton have been investigated and discussed by Ketchum (1954), Barlow (1955), Cronin, Daiber and Hulbert (1962) and Bayly(1965).

Ketchum showed that a stable population in the estuary is achieved at a level determined by the rate of reproduction of the species and therate of the circulation in the estuary. Barlow found that the interaction between physical hydrography of the estuary and the behaviour of the species have been the main factors involved in the maintenance of restricted distribution of plankton in the estuaries.

Cronin, Daider and Hulbert suggested that the two layer circulation pattern in the estuarine system and diurnal vertical migration which successively move the plankton between out flowing water and inflowing deeper waters would aid in the maintenance of a restricted horizontal distribution. Bayly discussed the problem and although no details of circulation of the Brisbane River was known, feels that some mechanism such as those of Cronin, Daider and Hulbert's two layer circulation system enables the Gladioferens population, in which he found some evidence of diurnal vertical migration, to maintain itself in a restricted manner in the river during high freshwater flow.

The geological structure and the hydrological features mainly the salinity depth profile, of the Derwent and Delaware River estuaries are very similar. Both Estuaries are long, deep and open directly to the ocean and also have a seasonal high freshwater flow. Since there is some evidence of diurnal vertical migration in Gladioferens species (Bayly, 1965), one of the major species in the Derwent estuary, the theory proposed by Cronin, Daiber and Hulbert could be important during periods of high freshwater flow. However, constant pressure from oceanic or coastal waters on the neritic marine zone could in turn uphold the estuarine region and could possibly be another factor for the maintenance of the restricted distribution of estuarine plankton populations.

Although continual changes take place between the oceanic, coastal and inshore coastal waters (Nyan Taw, 1975b and Section III of this thesis), there is no estuarine penetration into the inshore region nor is there any penetration of inshore plankton into the estuary. The tidal zone is stable and well defined and characterised by estuarine and marine species.

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APPENDIX I

RAW DATA - EAST COAST STUDY (SECTION II)

EAST COAST STATIONS

STATION	DATE	TIME	TEMPERATURE (°C)	SALINITY (‰)
CRUISE I				
1	18.VIII.71	1300	11.1	-
2	"	1120	10.9	-
3	"	0940	10.6	-
4	"	1430	11.1	-
CRUISE II				
5	16.XI.71	0800	11.7	-
6	"	1140	12.8	-
7	"	1300	12.8	-
8	"	1430	12.8	-
9	"	1720	12.8	-
10	"	1900	13.3	-
11	"	2030	12.8	-
12	17.XI.71	0840	12.2	-
13	"	1400	13.3	-
14	"	1560	13.3	-
15	"	1645	13.3	-
16	"	1800	12.8	-
CRUISE III				
17	15.XII.71	0900	13.3	-
18	"	1122	12.2	-
19	"	1240	13.6	-
20	"	1400	14.4	-
21	"	1700	14.4	-
22	"	1850	13.9	-
23	"	2000	13.3	-
24	16.XII.71	0645	12.8	-
25	"	1345	13.9	-
26	"	1415	13.9	-
27	"	1615	13.9	-
28	"	1810	13.3	-
CRUISE IV				
29	11.III.72	0735	-	-
CRUISE V				
30	18. IV.72	1100	15.9	-
31	"	0920	15.9	-
32	"	0740	16.1	-
33	"	0630	15.0	-
CRUISE VI				
34	23.VI.72	1610	13.3	35.69
35	"	1450	13.9	35.80
36	"	1340	14.1	-
37	"	1200	14.1	35.82

STATION	DATE	TIME	TEMPERATURE (^{o}C)	SALINITY (‰)
CRUISE VI				
38	22.VI.72	1605	14.4	35.79
39	"	1745	14.1	-
40	"	1915	13.9	-
41	"	2055	13.0	-
42	"	1320	14.1	35.84
43	"	1155	14.1	-
44	"	1030	14.4	-
45	"	0915	13.3	-
CRUISE VII				
46	22.VIII.72	0730	11.1	-
47	"	1015	12.2	-
48	"	1145	11.7	-
49	"	1315	11.7	35.11
50	"	1530	12.2	35.13
51	"	1645	12.2	-
52	"	1800	12.2	-
53	"	1915	12.2	-
54	23.VIII.72	1430	12.2	35.14
55	"	1615	12.2	-
56	"	1745	12.2	-
57	"	1915	10.0	-
CRUISE VIII				
58	17. X.72	0730	12.2	-
59	"	0840	12.2	-
60	"	1015	12.2	35.15
61	"	1135	12.5	35.16
62	"	1515	13.3	35.20
63	"	1650	12.8	35.11
64	"	1800	12.5	-
65	"	1910	12.8	-
66	18. X.72	1115	14.4	35.84
67	"	1255	14.4	35.85
68	"	1425	12.8	35.57
69	"	1600	12.8	35.19
CRUISE IX				
70	28.XI.72	0820	11.7	35.51
71	"	0945	13.6	35.75
72	"	1100	14.2	35.84
73	"	1220	14.3	35.87
74	"	1600	14.7	35.81
75	"	1740	14.6	35.86
76	"	1845	14.7	35.86
77	"	2012	13.3	35.53
78	29.XI.72	1230	14.7	35.87
79	"	1420	15.9	35.87
80	"	1545	15.6	35.87
81	"	1700	13.9	35.82

STATION	DATE	TIME	TEMPERATURE (°C)	SALINITY (‰)
CRUISE X				
82	31. V.73	1015	13.6	35.63
83	30. V.73	1930	13.9	35.62
84	"	1800	13.9	35.73
85	"	1610	14.0	37.74
86	"	1313	13.5	35.62
87	"	1145	14.1	35.71
88	"	1020	11.1	35.19
89	"	0855	11.1	35.18

	CRUISE I (stations 1-4)				CRUISE II (stations 5-16)									
STATIONS →	1	2	3	4	5	6	7	8	9	10	11	12	13	14
COPEPODS														
Calanus australis	14	62	1064	56	13	23	32	3	1	[illegible]	[illegible]	[illegible]		[illegible]
Mesocalanus tenuicornis	0	0	0	0	0	0	0	0	0	0	[illegible]	25	0	0
Neocalanus tonsus ad.	0	1	0	31	67	0	2	0	0	0	32	19	0	0
Neocalanus tonsus cop.V	0	0	0	0	24980	0	245	0	0	0	[illegible]	[illegible]	0	0
Calanoides carinatus	0	0	0	0	18	29500	591	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Calanus minor	2	9	0	16	0	0	0	0	0	1	0	0	0	0
Neocalanus robustior	0	0	0	4	0	0	0	0	0	15	0	0	0	0
Eucalanus attenuatus	0	1	0	1	1	0	0	1	0	17	4	0	0	0
Eucalanus crassus	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Eucalanus elongatus	1	0	0	1	0	0	0	0	0	23	37	0	0	[illegible]
Eucalanus longiceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mecynocera clausi	104	45	0	16	99	29	321	95	138	162	151	165	45	248
Rhincalanus nasutus	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Calocalanus contractus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calocalanus pavo	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calocalanus styliremis	0	0	0	0	0	0	0	0	0	0	0	3	0	1
Calocalanus tenuis	5	1	0	0	27	0	0	0	0	0	21	34	0	1
Leptocalanus plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	91	170	8022	320	57	0	0	0	0	13190	109	1538	[illegible]	2
Clausocalanus ingens	114	5460	71	220	18	12	10	21	0	2	10	11	0	
Clausocalanus laticeps	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Ctenocalanus vanus	0	2	6	3	0	0	0	0	0	440	40	39	0	0
Euchirella rostrata	0	0	0	0	1	0	0	0	0	0	21	0	0	0
Euchirella rostromagna	0	0	0	0	1	0	24	3	3	2	0	0	16	2
Undeuchaeta plumosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropages australiensis	2	260	15918	16	3	0	0	0	0	770	0	25	0	0
Centropages bradyi	4	0	0	1	0	0	0	0	0	2	6	0	0	0
Pleuromamma abdominalis	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Pleuromamma gracilis	0	0	0	1	0	0	0	0	0	1	290	3	1	0
Lucicutia flavicornis	0	0	0	0	0	0	0	0	0	0	23	0	0	0
Heterorhabdus papilliger	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Candacia bipinnata	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Labidocera tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acartia clausi	31	230	12838	430	36	0	0	0	0	26	0	512	0	0
Acartia danae	24	0	0	9	50	2	5	9	0	0	10	0	4	4
Oncaea conifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oncaea media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oncaea venusta	0	1	76	0	0	0	3	1	0	1	2	0	0	0
EUPHAUSIDS														
Euphausia lucens	0	0	0	0	0	4	2	0	0	0	0	0	0	0
Euphausia recurva	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nyctiphanes australis	0	2	0	1	3	0	0	0	0	0	4	[illegible]	0	0
Nematoscelis megalops	0	0	0	0	0	2	28	18	55	1	1	0	3	55
Thysanoessa gregaria	1	3	0	20	3	3	0	0	3	3	2	0	0	0
CHAETOGNATHS														
Pterosagitta draco	0	14	0	10	13	9	22	15	4	10	21	6	6	15
Sagitta gazellae	1	2	0	0	4	0	9	8	0	0	8	1	1	2
Sagitta hexaptera	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Sagitta lyra	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagitta minima	43	81	99	16	11	0	0	0	0	21	39	17	0	0
Sagitta planctonis	0	0	0	0	0	0	25	10	0	53	8	0	0	0
Sagitta serratodentata tasmanica	67	32	38	8	71	41	69		31	85	260	236	63	13
TUNICATES														
Pyrosoma atlanticum atlanticum	0	0	0	0	0	0	11	6	0	2	0	0	0	0
Ihlea magalhanica	0	0	0	0	0	0	2	6	10	1	0	0	0	0
Iasis zonaria	0	0	0	0	0	0	8	0	0	0	0	[illegible]	0	0
Thalia democratica	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0
Thetys vagina	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salpa fusiformis	0	11	0	0	0	0	0	0	0	0	0	0	0	[illegible]
Salpa maxima	0	0	0	0	0	0	0	0	0	0	0	0	0	0

continued

	CRUISE I (stations 1-4)				CRUISE II (stations 5-14)									
STATIONS →	1	2	3	4	5	6	7	8	9	10	11	12	13	14
COPEPODS														
Calanus australis	14	62	1064	54	13	23	32	[illegible]	-	1760	49	87	-	15
Mesocalanus tenuicornis	0	0	0	0	0	0	0	0	0	0	6	23	0	0
Neocalanus tonsus ad.	0	1	0	31	57	0	2	0	0	0	32	59	0	0
Neocalanus tonsus cop.V	0	0	0	0	24089	0	248	0	0	0	48700	112400	0	2
Calanoides carinatus	0	0	0	0	13	29500	591	23	1	37	620	1764	2330	11
Calanus minor	2	7	0	16	0	0	0	0	0	1	0	-	0	0
Neocalanus robustior	0	0	0	4	0	0	0	0	0	18	0	0	0	0
Eucalanus attenuatus	0	1	0	1	1	0	0	1	0	17	4	0	0	0
Eucalanus crassus	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Eucalanus elongatus	1	0	0	1	0	0	0	0	0	29	27	0	0	12
Eucalanus longiceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mecynocera clausi	104	45	0	16	99	29	321	45	158	162	151	168	46	248
Rhincalanus nasutus	0	0	0	1	0	0	0	0	0	0	0	0	0	[illegible]
Calocalanus contractus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calocalanus pavo	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calocalanus styliremis	0	0	0	0	0	0	0	0	1	0	0	3	0	1
Calocalanus tenuis	5	1	0	0	27	0	0	0	0	0	21	39	0	1
Leptocalanus plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	91	170	8022	320	57	0	0	0	0	13190	109	1536	7	2
Clausocalanus ingens	114	5460	71	220	18	12	10	21	0	2	18	11	0	1
Clausocalanus laticeps	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Ctenocalanus vanus	0	2	6	3	0	0	0	0	0	440	40	39	0	0
Euchirella rostrata	0	0	0	0	1	0	0	0	0	0	21	0	0	0
Euchirella rostromagna	0	0	0	0	1	0	24	3	3	2	0	0	16	2
Undeuchaeta plumosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropages australiensis	2	260	15918	16	3	0	0	0	0	770	0	25	0	0
Centropages bradyi	4	0	0	1	0	0	0	0	0	2	8	0	0	0
Pleuromamma abdominalis	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Pleuromamma gracilis	0	0	0	1	0	0	0	0	0	1	290	3	1	0
Lucicutia flavicornis	0	0	0	0	0	0	0	0	0	0	23	0	0	0
Heterorhabdus papilliger	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Candacia bipinnata	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Labidocera tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acartia clausi	31	230	12838	430	36	0	0	0	0	26	0	812	0	0
Acartia danae	24	0	0	9	50	2	5	9	0	0	10	0	4	4
Oncaea conifera	0	0	0	0	0	0	0	0	0		0	0	0	0
Oncaea media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oncaea venusta	0	1	76	0	0	0	3	1	0	1	2	0	0	0
EUPHAUSIDS														
Euphausia lucens	0	0	0	0	0	4	2	0	0	0	0	[illegible]	0	0
Euphausia recurva	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nyctiphanes australis	0	2	0	1	3	0	0	0	[illegible]	0	4	14	0	0
Nematoscelis megalops	0	0	0	0	0	2	28	18	55	1	1	[illegible]	3	58
Thysanoessa gregaria	1	3	0	20	3	3	0	0	3	3	2	0	0	0
CHAETOGNATHS														
Pterosagitta draco	0	14	0	10	13	9	22	15	4	10	21	6	6	15
Sagitta gazellae	1	2	0	0	4	0	9	8	0	0	8	1	1	2
Sagitta hexaptera	0	0	0	3	0	0	0	0	0	0	0	[illegible]	0	0
Sagitta lyra	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagitta minima	45	81	99	16	11	0	0	0	0	21	39	17	0	0
Sagitta planctonis	0	0	0	0	0	0	25	10	0	53	8	0	0	0
Sagitta serratodentata tasmanica	67	32	38	8	71	41	69		31	85	260	238	63	13
TUNICATES														
Pyrosoma atlanticum atlanticum	0	0	0	0	0	0	11	[illegible]	0	2	0	0	0	0
Ihlea magalhanica	0	0	0	0	0	0	2	5	10	1	0	0	0	0
Iasis zonaria	0	0	0	0	0	0	8	0	0	0	0	0	0	0
Thalia democratica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thetys vagina	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salpa fusiformis	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Salpa maxima	0	0	0	0	0	0	0	0	0	0	0	0	0	0

continued

			CRUISE III (stations 17-27)										
STATIONS →	[illegible]	16	17	18	19	20	21	22	23	24	25	26	27
COPEPODS													
C. australis	150	376	10654	17970	92	43	142	24	522	10500	33	190	107
R. tenuicornis	1	62	1	0	0	0	0	0	0	0	0	55	0
N. tonsus ad.	0	0	0	0	0	0	0	0	0	0	0	0	4
N. tonsus cop. V	40400	154	1862	4200	12	0	0	0	19600	277	0	2	21
C. carinatus	16200	3	337	5300	104	490	122	340	49	41	31	0	390
C. minor	0	7	3	0	0	0	0	0	0	0	0	0	0
N. robustior	0	3	0	0	0	0	0	0	0	0	0	0	0
E. attenuatus	2	1	0	1	2	5	4	1	0	0	0	0	3
E. crassus	0	0	0	0	0	1	0	0	0	0	0	0	0
E. elongatus	6	0	1	1	46	75	310	101	0	0	114	12	13
E. longiceps	0	0	0	0	1	3	0	1	0	1	3	0	0
M. clausi	66	59	111	66	440	350	192	54	62	78	62	156	24
R. nasutus	3	0	0	0	14	108	12	14	1	0	41	3	28
C. contractus	0	0	0	1	0	0	0	0	0	0	0	0	0
C. pavo	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	17	1	1	2	0	0	0	0	0	0	0
C. tenuis	6	0	27	5	19	6	21	8	16	8	3	2	11
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0
P. parvus	62	7462	106860	16090	42	0	0	0	158500	9660	0	0	69
C. incens	22	3	356	150	248	610	760	182	28	29	910	1650	22
C. laticeps	0	0	0	0	0	0	0	0	0	0	0	0	0
C. vanus	0	2716	139	55	0	0	0	0	12	20	0	0	0
E. rostrata	0	1	4	1	0	0	0	0	1	0	0	0	22
E. rostromagna	2	0	0	0	0	0	0	0	0	0	0	0	0
U. plumosa	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	0	168	72	12	0	0	1	0	29	34	0	0	0
C. bradyi	0	50	15	26	0	2	1	4	102	0	2	5	2
P. abdominalis	0	8	0	0	0	0	0	0	0	0	0	0	8
P. gracilis	0	185	0	0	0	0	0	0	0	0	0	0	0
L. flavicornis	0	4	0	0	0	0	0	0	0	0	0	0	0
H. papilliger	0	4	0	0	0	0	0	0	0	0	0	0	0
C. bipinnata	1	8	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	1	0	0	0	0	0	0	0	0	0	0
A. clausi	0	269	1148	18	7	0	0	0	18	980	0	0	0
A. danae	4	0	0	0	0	1	0	3	0	0	0	3	2
O. conifera	0	0	1	2	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0	0	0	0	0	1	0	0	0	0
O. venusta	0	10	1	0	1	1	0	7	0	0	0	1	8
EUPHAUSIDS													
E. lucens	35	0	0	0	0	0	0	0	2	0	3	0	0
E. recurva	0	0	0	0	0	0	0	0	0	0	0	0	0
N. australis	0	0	0	0	0	0	0	0	0	0	0	0	0
N. megalops	0	0	0	1	0	0	0	0	0	0	36	5	0
T. gregaria	2	0	0	1	0	0	1	8	8	0	2	5	0
CHAETOGNATHS													
P. drago	1	0	3	9	6	1	1	4	0	0	0	2	1
S. gazellae	3	0	1	1	1	2	0	1	0	0	4	0	0
S. hexaptera	0	0	0	0	0	0	0	0	0	00	0	0	0
S. lyra	0	22	1	0	0	0	0	0	0	0	0	0	6
S. minima	0	199	29	15	3	31	7	9	98	22	17	1	6
S. planctonis	1	0	0	0	0	0	0	2	0	0	0	0	[illegible]
S. s. tasmanica	82	3	92	189	750	26	530	2330	620	0	172	280	26
TUNICATES													
P. a. atlanticum	2	0	0	0	0	0	0	0	0	0	0	0	0
I. magalhanica	0	0	0	0	0	0	0	0	0	0	0	0	0
I. zonaria	0	0	0	0	0	7	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	0	0	0	0
T. vagina	0	0	0	0	0	0	0	0	0	0	0	0	0
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. maxima	0	0	0	0	0	0	0	0	0	0	0	0	0

continued

		CRUISE IV	CRUISE V (stations 30–33)				CRUISE VI (stations 34–45)						
STATIONS →	28	29	30	31	32	33	34	35	36	37	38	39	40
COPEPODS													
C. australis	3048	2870	0	0	530	1560	102	2	2	1	0	[illegible]	[illegible]
N. tenuicornis	0	0	0	0	0	0	0	2	0	0	0	[illegible]	[illegible]
N. tonsus ad.	0	0	0	0	0	0	0	0	4	0	0	[illegible]	[illegible]
N. tonsus cop. V	1106	0	0	0	0	1	0	0	0	0	0	[illegible]	[illegible]
C. carinatus	55	3	0	0	0	0	0	0	0	0	0	0	0
C. minor	0	6	9	1	710	148	18	11	0	3	0	31	3
N. robustior	0	0	0	0	12	1	2	1	0	0	3	196	0
E. attenuatus	0	0	0	0	0	0	0	0	0	0	0	0	0
E. crassus	0	1	0	1	0	0	0	0	0	0	0	0	0
E. elongatus	2	7	11	17	520	14	0	0	0	0	0	0	0
E. longiceps	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	57	50	1	6	11	41	25	21	0	19	0	2	0
R. nasutus	6	0	0	1	132	8	0	0	0	0	0	0	0
C. contractus	0	0	0	0	0	0	0	0	0	0	0	0	0
C. pavo	0	0	0	0	1	1	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	4	14	1	1	2	4	11	0	0	0	0	0	0
L. plumulosus	0	0	14	9	2	1	0	0	0	0	0	0	0
P. parvus	36680	2520	0	0	31	9772	2254	0	0	0	0	0	0
C. ingens	8	994	60	26	960	686	29	7230	22	203	6	0	9
C. laticeps	0	0	0	0	0	0	0	0	0	0	0	0	0
C. vanus	350	6	0	0	200	36	0	0	0	0	0	0	0
E. rostrata	0	0	0	0	0	0	0	0	0	0	0	0	0
E. rostromagna	0	0	0	0	0	0	0	0	0	0	0	0	0
U. plumosa	0	0	0	0		0	0	0	0	0	0	34	0
C. australiensis	2	1	0	1	7	224	15	0	0	0	0	0	0
C. bradyi	0	6	35	8	120	113	24	10	0	3	0	32	3
P. abdominalis	0	0	0	0	5	1	0	0	0	0	0	62	6
P. gracilis	0	0	0	0	3	43	6	0	0	0	0	242	56
L. flavicornis	0	0	0	0	0	0	0	0	0	0	0	0	0
H. papilliger	0	0	0	0	0	0	0	0	0	0	0	27	0
C. bipinnata	0	1	0	0	162	0	2	0	0	0	0	51	1
L. tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0
A. clausi	91	0	0	0	12	798	59	0	0	0	0	0	0
A. danae	0	770	2030	720	2980	1134	17	18	5	106	2	3	0
O. conifera	0	0	0	2	220	3	0	0	0	0	0	0	0
O. media	0	0	0	0	2	0	6	1	0	0	0	2	[illegible]
O. venusta	0	1	0	0	5	10	0	0	0	0	0	0	0
EUPHAUSIDS													
E. lucens	0	0	0	0	0	0	0	0	0	0	0	0	0
E. recurva	0	0	3	86	0	0	0	0	0	0	0	18	0
N. australis	0	3	0	0	0	52	3	0	0	0	0	0	11
N. megalops	0	0	8	2	0	0	0	0	0	0	0	0	1
T. gregaria	0	3	14	12	2	1	5	11	0	7	0	2	0
CHAETOGNATHS													
P. draco	0	17	0	0	2	1	2	0	0	0	0	0	0
S. gazellae	0	0	0	0	0	0	0	0	0	0	0	0	0
S. hexaptera	0	1	0	0	1	0	0	0	0	0	0	0	0
S. lyra	0	13	0	0	3	1	15	44	0	0	0	13	1
S. minima	74	10	0	0	21	15	113	7	0	0	0	21	[illegible]
S. planctonis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. s. tasmanica	53	214	0	0	250	154	85	86	1	71	6	171	4
TUNICATES													
P. a. atlanticum	0	3	0	1	8	18	0	32	0	2	0	32	2
I. magalhanica	0	4	0	0	0	0	0	0	0	0	0	0	0
I. zonaria	0	7	0	0	0	0	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	0	0	0	0
T. vagina	0	0	0	0	0	0	0	0	0	0	5	0	2
S. fusiformis	0	36	21	0	2	0	0	0	0	0	0	0	0
S. maxima	0	0	0	0	0	0	0	0	0	0	2900	23	155

continued

						CRUISE VII (stations 46-57)							
STATIONS →	41	42	43	44	45	46	47	48	49	50	51	52	53
COPEPODS													
C. australis	273	0	0	21	560	59	32	3	4	0	0	26	[illegible]
N. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0
N. tonsus ad.	0	0	0	0	0	337	68	13	91	893	262	61	6
N. tonsus cop. V	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	1	0	0	0	0	0	0
C. minor	6	6	1	23	22	13	4	1	0	0	2	4	0
N. robustior	4	31	9	46	4	0	0	0	0	0	0	0	0
E. attenuatus	0	0	0	0	0	3	0	1	0	0	0	0	0
E. crassus	0	0	0	0	0	0	0	0	0	0	0	0	0
E. elongatus	0	0	0	0	0	0	0	0	0	0	0	0	0
E. longiceps	0	0	0	0	0	0	0	1	0	0	0	0	0
M. clausi	[illegible]	0	0	0	39	30	56	68	1	2	4	8	15
R. nasutus	0	0	0	0	0	0	0	0	0	0	0	0	0
C. contractus	0	0	0	0	0	0	0	0	0	0	0	0	0
C. pavo	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	3	0	0	0	0	6	6	4	0	1	0	0	3
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0
P. parvus	27874	0	0	0	1631	297	0	0	0	0	0	0	1259
C. ingens	17	131	112	23	517	438	2290	340	14	156	18	138	8
C. laticeps	0	0	0	0	0	0	0	3	0	5	0	0	0
C. vanus	0	0	0	11	2	0	0	0	0	0	0	0	0
E. rostrata	0	0	0	1	0	0	0	0	0	0	0	0	0
E. rostromagna	0	0	0	0	0	0	0	0	0	0	0	0	0
U. plumosa	0	0	0	0	0	18	1	0	0	0	0	3	0
C. australiensis	490	0	0	0	560	8	4	0	0	0	0	3	21
C. bradyi	10	0	1	32	36	0	2	26	1	0	0	0	3
P. abdominalis	0	0	0	0	2	24	0	0	0	0	0	0	0
P. gracilis	3	0	0	0	6	125	1	0	0	0	0	2	15
L. flavicornis	0	0	0	0	0	0	0	0	0	0	0	0	29
H. papilliger	0	0	0	0	0	5	0	0	0	0	0	4	13
C. bipinnata	2	0	0	81	20	0	0	0	0	0	0	0	3
L. tasmanica	2	0	0	0	0	0	0	0	0	0	0	0	2
A. clausi	1946	0	0	0	8430	116	0	0	0	0	0	0	204
A. danae	20	6	8	23	39	6	121	2	0	0	0	18	14
O. conifera	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	2	2	5	0	0	0	0	0	0	3
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHAUSIDS													
E. lucens	0	0	0	0	0	0	3	0	0	0	0	0	0
E. recurva	0	0	0	0	0	0	0	0	0	0	0	0	0
N. australis	0	0	0	0	10	0	0	0	0	0	0	8	0
N. megalops	0	0	0	0	0	0	0	0	0	0	0	0	0
T. gregaria	0	14	3	3	0	16	290	74	137	113	21	77	3
CHAETOGNATHS													
P. drago	0	0	0	0	0	2	0	0	0	0	0	0	0
S. gazellae	0	0	0	0	0	0	0	6	10	21	10	3	0
S. hexaptera	0	0	0	0	0	8	0	0	0	0	0	0	0
S. lyra	1	24	2	0	0	0	0	0	0	0	0	0	0
S. minima	36	0	0	31	90	4	0	0	0	0	0	5	0
S. planctonis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. s. tasmanica	53	37	41	45	91	0	0	0	0	0	5	0	0
TUNICATES													
P. a. atlanticum	2	1	1	0	0	0	0	0	0	0	0	0	0
F. magalhanica	0	0	0	0	0	0	0	0	0	0	0	0	0
I. zonaria	0	0	0	0	0	0	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	0	0	0	0
T. vagina	0	3	0	0	0	0	0	0	0	0	0	0	0
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. maxima	0	510	96	0	0	0	0	0	0	0	0	0	0

continued

					CRUISE VIII (stations 58-69)								
STATIONS →	54	55	56	57	58	59	60	61	62	63	64	65	66
COPEPODS													
C. australis	0	2	82	99	525	6	2	2	6350	106	445	1106	8300
N. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	13	0
N. tonsus ad.	1788	16470	142	546	70	2650	4000	10145	365	5050	550	0	145
N. tonsus cop. V	0	0	0	0	14595	58450	34450	11425	3220	41300	24800	45220	4200
C. carinatus	0	0	0	0	0	105	76	62	1105	405	14	7	5850
C. minor	0	0	2	0	0	0	0	0	3	0	2	3	65
N. robustior	0	0	34	2	0	0	0	0	0	0	0	0	40
E. attenuatus	0	1	1	0	0	4	5	7	0	2	0	0	18
E. crassus	0	0	0	0	0	0	0	0	4	0	0	0	14
E. elongatus	0	0	0	0	0	5	10	4	8	17	0	0	453
E. longiceps	0	2	0	1	0	34	11	6	330	2	0	0	4
M. clausi	8	0	11	2	43	155	80	50	26	140	115	29	30
R. nasutus	0	0	0	0	0	0	0	0	42	3	0	0	1132
C. contractus	0	0	0	0	17	2	2	1	11	4	2	2	0
C. pavo	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	30	42	16	16	16	17	14	3	1
C. tenuis	3	0	4	2	16	19	11	8	46	24	8	87	10
L. plumulosus	0	0	0	0	0	0	0	0	1	0	0	0	51
P. parvus	0	0	243	2930	72170	3	0	0	57425	121	262	218120	30750
C. ingens	110	1990	116	616	804	156	86	15	205	17	74	343	20
C. laticeps	0	0	0	0	0	5	7	1	6	0	10	0	0
C. vanus	0	0	0	0	308	2	0	0	0	0	48	392	5
E. rostrata	0	0	0	0	4	26	405	385	0	75	2	5	0
E. rostromagna	0	0	0	0	0	1	4	6	0	3	0	0	0
U. plumosa	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	0	0	6	94	275	0	0	0	275	0	0	1255	3300
C. bradyi	1	1	0	2	44	35	26	11	75	2	50	37	75
P. abdominalis	0	0	0	7	0	0	0	0	0	0	0	0	0
P. gracilis	0	0	2	7	3	0	0	0	0	0	0	4	0
L. flavicornis	0	0	0	15	0	0	0	0	0	0	0	0	0
H. papilliger	0	0	2	50	0	0	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	3	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0	2	2	0	0	0	0	0	1	5	0
A. clausi	0	0	0	197	250	0	0	0	2	0	16	15300	150
A. danae	0	0	19	0	9	0	0	2	4	0	0	0	55
O. conifera	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0	20	0	0	0	12	0	1	0	0
O. venusta	0	0	1	2	0	7	5	1	11	0	1	0	590
EUPHAUSIDS													
E. lucens	0	0	0	0	0	0	0	7	0	22	0	0	0
E. recurva	0	0	0	0	0	0	0	0	0	0	0	0	0
N. australis	0	0	0	6	0	0	0	0	0	0	0	3	0
N. megalops	0	0	0	0	0	0	0	0	0	0	0	0	0
T. gregaria	0	91	6	0	2	1	8	11	7	10	2	0	1
CHAETOGNATHS													
P. drago	0	0	0	0	3	0	0	0	4	1	3	2	6
S. gazellae	2	11	0	0	6	32	63	78	2	11	0	0	0
S. hexaptera	0	0	0	0	0	0	0	0	0	0	0	0	0
S. lyra	0	0	6	5	0	0	0	0	0	0	0	0	0
S. minima	0	0	20	11	365	2	1	3	79	2	96	11	590
S. planctonis	0	0	0	0	20	109	60	116	0	0	0	0	0
S. s. tasmanica	0	0	0	0	143	148	81	85	107	260	189	301	525
TUNICATES													
P. a. atlanticum	0	0	0	0	0	0	0	0	0	0	0	0	0
I. magalhanica	0	0	0	0	0	0	0	0	0	0	0	0	0
I. zonaria	0	0	0	0	0	0	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	0	0	0	2
T. vagina	0	0	0	0	0	0	0	0	0	0	0	0	0
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. maxima	0	0	0	0	0	0	0	0	0	0	0	0	0

continued

				CRUISE IX (stations 70-81)								
STATIONS →	67	68	69	70	71	72	73	74	75	76	77	78
COPEPODS												
C. australis	5050	1615	33810	868	16220	341	[illegible]	1	52	360	28	390
M. tenuicornis	10	2	8	0	0	0	0	0	0	0	0	0
N. tonsus ad.	6	32	0	0	0	0	0	0	0	0	0	0
N. tonsus cop. V	210	12870	861	11298	2170	0	0	0	0	300	347200	0
C. carinatus	575	3	14	20	400	1	0	0	13	17	6	11
C. minor	45	3	0	0	0	2	2	0	3	3	0	17
N. robustior	0	0	0	0	0	1	7	0	0	3	0	11
E. attenuatus	56	0	0	0	4	12	8	0	15	2	0	8
E. crassus	53	0	0	1	3	0	0	0	3	2	0	0
E. elongatus	873	0	0	0	48	32	16	2	36	92	0	64
E. longiceps	5	1	0	9	7	0	0	0	0	6	0	0
N. clausi	10	126	28	43	140	840	810	13	410	151	17	860
R. nasutus	250	0	0	0	1	0	0	0	0	5	0	0
C. contractus	0	2	0	20	3	0	0	0	0	0	0	0
C. pavo	0	0	0	0	0	0	0	1	0	0	0	1
C. styliremis	10	9	0	17	0	3	0	0	1	1	0	0
C. tenuis	40	46	84	49	6	28	11	1	23	10	28	16
L. plumulosus	9	2	1	0	0	0	0	0	0	0	0	0
P. parvus	15075	8875	175420	16212	1760	1	0	0	42	1230	8456	360
C. ingens	150	53	252	238	76	48	47	2	2	6	34	69
C. laticeps	0	7	0	6	1	0	0	0	0	0	0	0
C. vanus	340	345	1054	67	360	0	0	0	0	390	28	170
E. rostrata	0	4	0	0	1	0	0	0	0	1	0	0
E. rostromagna	0	0	0	0	0	0	1	0	0	0	0	0
U. plumosa	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	75	21	6050	36	162	1	0	0	18	34	330	0
C. bradyi	160	43	26	31	24	14	4	0	5	17	0	17
P. abdominalis	0	0	0	8	0	0	0	0	0	10	0	0
P. gracilis	0	0	0	3	0	0	0	0	0	35	0	0
L. flavicornis	0	0	0	1	0	0	0	0	0	8	6	0
H. papilliger	0	0	0	0	0	0	0	0	0	3	0	2
C. bipinnata	0	0	3	1	0	0	0	0	0	0	0	0
L. tasmanica	0	0	49	0	0	0	0	0	0	0	0	0
A. clausi	25	56	10800	2618	69	0	0	0	1	3	568	0
A. danae	85	13	14	0	50	690	390	259	114	67	0	21
O. conifera	0	0	0	0	0	0	0	0	0	2	0	0
O. media	25	3	7	3	0	0	1	0	0	0	0	0
O. venusta	605	3	4	0	38	8	17	0	8	8	0	37
EUPHAUSIDS												
E. lucens	0	0	0	0	0	0	0	0	0	0	0	0
E. recurva	0	0	0	0	0	0	0	0	0	0	0	0
N. australis	0	2	0	150	26	0	0	0	0	0	118	0
N. megalops	0	0	0	0	0	0	2	2	0	0	0	0
T. gregaria	0	0	0	2	3	0	0	35	1	0	0	1
CHAETOGNATHS												
P. draco	7	3	0	0	3	4	1	12	31	6	0	6
S. gazellae	0	0	0	1	0	0	0	0	0	0	0	0
S. hexaptera	0	0	0	0	0	0	0	0	0	0	0	0
S. lyra	0	0	0	1	0	0	0	0	0	3	0	0
S. minima	91	4	84	3	39	11	4	0	46	165	22	69
S. planctonis	0	1	0	0	0	0	3	0	0	0		
S. s. tasmanica	272	16	0	104	890	550	580	1660	270	180	0	540
TUNICATES												
P. a. atlanticum	0	0	0	0	0	0	0	0	0	0	0	0
I. magalhanica	0	0	0	0	230	0	0	115	31	42	0	0
I. zonaria	0	0	0	0	0	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	3	0	3
T. vagina	0	0	0	0	0	0	0	0	0	0	0	0
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	18
S. maxima	0	0	0	0	0	0	0	0	0	0	0	0

continued

				CRUISE X (stations 82-89)							
STATIONS →	79	80	81	82	83	84	85	86	87	88	89
COPEPODS											
C. australis	26	3900	854	440	34	400	168	4	10	460	1246
R. tenuicornis	0	0	0	0	0	0	0	0	0	0	112
N. tonsus ad.	0	0	0	0	0	0	0	3	2	0	0
N. tonsus cop. V	0	0	36	0	0	0	0	0	0	0	0
C. carinatus	1	590	22	0	0	0	0	2	0	0	0
C. minor	2	160	5	27	4	63	29	0	39	72	22
N. robustior	0	3	0	4	17	1	3	1	1	3	3
E. attenuatus	2	7	1	0	0	0	0	0	0	0	1
E. crassus	1	140	6	3	0	0	0	0	1	0	0
E. elongatus	48	1170	15	220	130	1	1	19	141	1	1
E. longiceps	0	2	0	0	0	0	0	0	0	0	0
M. clausi	150	30	37	71	63	230	330	650	1170	410	448
R. nasutus	5	220	10	490	290	0	0	20	144	0	13
C. contractus	0	0	0	0	0	0	0	0	1	0	0
C. pavo	0	0	0	0	0	0	0	0	2	0	0
C. styliremis	0	0	0	0	0	0	0	0	1	0	0
C. tenuis	8	24	3	5	2	0	7	1	35	8	6
L. plumulosus	0	0	0	0	0	0	0	1	12	0	0
P. parvus	7	7740	10598	0	0	312	16548	0	0	680	13832
C. ingens	3	31	60	2340	32	1440	132	16830	1020	1730	434
C. laticeps	0	0	0	0	0	0	0	0	0	0	0
C. vanus	1	68	21	2	0	0	104	0	0	0	196
E. rostrata	0	0	1	0	0	0	0	0	0	0	0
E. rostromagna	0	0	0	0	0	0	0	0	0	0	0
U. plumosa	0	0	0	0	52	0	0	0	0	0	0
C. australiensis	0	2850	2562	0	0	0	124	0	1	0	154
C. bradyi	3	78	22	48	4	106	22	2	101	21	266
P. abdominalis	0	0	1	0	240	1	0	0	0	0	1
P. gracilis	0	0	8	4	12660	240	73	3	8	0	1
L. flavicornis	0	0	0	0	310	3	0	0	0	0	0
H. papilliger	0	0	0	0	47	2	0	0	0	1	0
C. bipinnata	0	125	0	0	2	2	0	0	0	2	2
L. tasmanica	0	0	3	0	0	0	0	0	0	0	0
A. clausi	0	490	420	0	0	18	3556	0	2	210	784
A. danae	360	80	22	42	2	82	60	16	160	49	17
O. conifera	0	0	0	0	120	0	0	0	0	0	0
O. media	0	36	1	1	1	0	1	0	1	3	3
O. venusta	1	620	57	7	0	0	1	0	15	0	3
EUPHAUSIDS											
E. lucens	0	0	0	0	25	11	0	0	0	1	0
E. recurva	0	0	0	0	3	0	0	0	0	0	0
N. australis	0	0	0	0	0	28	6	0	0	0	0
N. megalops	0	0	0	2	0	2	1	1	2	0	0
T. gregaria	1	0	0	6	2	35	3	2	3	37	0
CHAETOGNATHS											
P. draco	7	11	0	1	0	3	0	0	1	3	0
S. gazellae	0	0	0	0	0	0	0	0	0	0	0
S. hexaptera	0	0	0	0	0	0	0	0	1	0	0
S. lyra	0	0	1	10	0	0	0	0	7	0	6
S. minima	18	560	32	31	21	118	67	16	300	52	476
S. planctonis	0	0	0	0	0	0	0	0	0	0	0
S. s. tasmanica	79	740	6	31	12	122	64	31	24	730	634
TUNICATES											
P. a. atlanticum	0	0	0	0	0	0	0	0	0	0	0
I. magalhanica	0	1430	0	0	0	0	0	0	0	0	0
I. zonaria	0	0	0	0	0	0	0	0	0	0	0
T. democratica	0	0	0	0	0	0	0	0	0	0	0
T. vagina	0	0	0	0	0	0	0	0	0	0	0
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0
S. maxima	0	0	0	0	0	0	0	0	0	0	0

(Species occurring once or twice are not included in the list.)

Percentage of Species-groups.

Station Nos.	1		2		3		4		5	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	124	96.12	662	94.44	28756	99.74	767	92.19	79	47.59
II. Sub-Tropical	2	1.56	9	1.28	0	0	22	2.64	0	0
III. Sub-Tropical	1	0.78	11	1.57	0	0	0	0	0	0
IV. Sub-Tropical	1	0.78	16	2.28	76	0.26	12	1.44	13	7.83
V. Sub-Antarctic	1	0.78	3	0.43	0	0	31	3.73	74	44.58

Station Nos.	6		7		8		9		10	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	0	0	0	0	0	0	0	0	13986	99.21
II. Sub-Tropical	0	0	0	0	0	0	0	0	20	0.14
III. Sub-Tropical	2	18.18	41	32.54	30	46.15	65	90.28	4	0.03
IV. Sub-Tropical	9	81.82	25	19.84	16	24.62	4	5.56	32	0.23
V. Sub-Antarctic	0	0	60	47.62	18	27.69	3	4.17	55	0.39

Station Nos.	11		12		13		14		15	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	113	21.48	2389	97.07	7	20.59	2	2.15	62	80.52
II. Sub-Tropical	293	55.70	3	0.12	1	2.94	0	0	1	1.30
III. Sub-Tropical	1	0.19	0	0	3	8.82	58	62.37	2	2.60
IV. Sub-Tropical	50	9.51	6	0.24	6	17.65	27	29.03	6	7.79
V. Sub-Antarctic	69	13.12	63	2.56	17	50.00	6	6.45	6	7.79

	16		17		18		19		20	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	437	64.17	162107	99.99	16121	99.9	49	41.18	0	0
II. Sub-Tropical	233	34.21	4	0.001	0	0	0	0	0	0
III. Sub-Tropical	0	0	0	0	1	0.01	0	0	8	4. 00
IV. Sub-Tropical	10	1.47	5	0.001	9	0.06	67	56.30	185	92.50
V. Sub-Antarctic	1	0.15	22	0.01	4	0.03	3	2.52	7	3.50

	21		22		23		24		25	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	0	0	0	0	158547	99.997	10674	99.99	0	0
II. Sub-Tropical	0	0	0	0	1	0.001	0	0	0	0
III. Sub-Tropical	0	0	0	0	0	0	0	0	36	18.27
IV. Sub-Tropical	323	100	126	96.92	1	0.001	0	0	155	78.68
V. Sub-Antarctic	0	0	4	3.08	1	0.001	1	0.01	6	3.05

	26		27		28		29		30	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	0	0	89	49.17	36774	99.98	2521	96.85	0	0
II. Sub-Tropical	0	0	14	7.74	0	0	13	0.50	9	13.64
III. Sub-Tropical	5	21.74	0	0	0	0	44	1.69	46	69.70
IV. Sub-Tropical	18	78.26	51	28.18	8	0.02	25	0.96	11	16.67
V. Sub-Antarctic	0	0	27	14.92	0	0	0	0	0	0

Station		I. Coastal	II. Sub-Tropical	III. Sub-Tropical	IV. Sub-Tropical	V. Sub-Antarctic
31	No.	1	1	99	18	0
	%	0.84	0.84	83.19	15.13	0
32	No.	50	897	12	659	0
	%	3.09	55.44	0.74	40.73	0
33	No.	10794	194	22	33	0
	%	97.74	1.76	0.20	0.30	0
34	No.	2331	49	0	2	0
	%	97.86	2.06	0	0.08	0
35	No.	21	57	32	0	0
	%	19.09	51.82	29.09	0	0
36	No.	0	0	0	0	4
	%	0	0	0	0	100
37	No.	0	3	2	0	0
	%	0	60	40	0	0
38	No.	0	3	2900	0	0
	%	0	0.10	99.90	0	0
39	No.	0	597	73	0	0
	%	0	89.10	10.89	0	0
40	No.	11	67	159	0	0
	%	4.64	28.27	67.09	0	0
41	No.	30310	16	2	0	0
	%	99.94	0.05	0.01	0	0
42	No.	0	61	511	0	0
	%	0	10.66	89.34	0	0
43	No.	0	12	97	0	0
	%	0	11.01	88.99	0	0
44	No.	0	152	57	1	1
	%	0	72.04	27.04	0.47	0.47
45	No.	10631	86	0	0	0
	%	99.20	0.80	0	0	0

	46		47		48		49		50		51		52		53	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	421	44.55	4	5.06	0	0	0	0	0	0	0	0	11	12.79	1524	98.26
II. Sub-Tropical	167	17.67	5	6.33	7	23.33	0	0	0	0	2	0.72	11	12.79	21	1.35
III. Sub-Tropical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IV. Sub-Tropical	2	0.21	2	2.53	0	0	0	0	0	0	0	0	0	0	0	0
V. Sub-Antarctic	355	37.57	68	86.07	23	76.67	201	100	919	100	276	999.28	64	74.42	6	0.39

	54		55		56		57		58		59		60	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	0	0	0	0	249	57.11	3227	85.00	72695	99.76	3	0.10	0	0
II. Sub-Tropical	0	0	0	0	44	10.09	21	0.55	26	0.04	0	0	0	0
III. Sub-Tropical	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IV. Sub-Tropical	0	0	0	0	1	0.23	2	0.05	3	0.004	12	0.41	15	0.33
V. Sub-Antarctic	1790	100	1648	100	142	32.57	547	1441	147	0.20	2901	99.49	4568	99.74

	61		62		63		64		65	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	0	0	57702	98.61	121	2.28	278	32.21	234678	99.92
II. Sub-Tropical	0	0	15	0.03	0	0	3	0.35	7	0.03
III. Sub-Tropical	0	0	5	0.01	0	0	0	0	0	0
IV. Sub-Tropical	5	0.05	65	0.11	21	0.41	4	0.46	2	0.010
V. Sub-Antarctic	10753	99.95	724	1.24	5162	97.32	578	66.98	10	0.04

	66		67		68		69		70	
	No.	%	No.	%	No.	%	No.	%	No.	
I. Coastal	49850	95.22	15175	88.93	8923	99.22	192270	99.992	19016	99.66
II. Sub-Tropical	105	0.20	70	0.41	6	0.07	10	0.005	16	0.08
III. Sub-Tropical	65	0.12	62	0.36	2	0.02	1	0.001	1	0.01
IV. Sub-Tropical	2183	4.17	1735	10.17	6	10.07	4	0.002	0	0
V. Sub-Antarctic	149	0.29	22	0.13	56	0.62	0	0	48	0.25

	71		72		73		74		75	
	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	2017	85.76	2	3.85	0	0	0	0	61	35.67
II. Sub-Tropical	0	0	3	5.77	10	20	0	0	3	1.75
III. Sub-Tropical	233	9.91	0	0	2	4	117	89.31	31	18.13
IV. Sub-Tropical	90	3.83	44	84.62	34	68	14	10.69	75	43.86
V. Sub-Antarctic	12	0.51	3	5.77	4	8	0	0	1	0.58

	76		77		78		79		80		81		82		83		84		85		86		87		88		89	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Coastal	1264	85.35	9778	100	360	70.18	7	7.33	11080	71.04	13160	99.21	0	0	0	0	358	53.35	20234	99.46	0	0	3	0.79	890	91.47	14770	99.41
II. Sub-Tropical	54	3.65	0	0	28	5.46	2	2.67	324	2.08	16	0.12	46	5.55	12924	96.81	307	45.75	108	0.53	4	8.33	56	14.78	79	8.12	70	0.47
III. Sub-Tropical	44	2.97	0	0	18	3.51	1	1.33	1570	10.07	6	0.05	5	0.60	3	0.02	2	0.30	1	0.01	2	4.17	15	3.96	0	0	0	0
IV. Sub-Tropical	111	7.50	0	0	107	20.86	64	85.33	2621	16.80	82	0.62	778	93.85	420	3.15	4	0.60	1	0.01	39	81.25	301	79.42	4	0.41	17	0.11
V. Sub-Antarctic	8	0.54	0	0	0	0	1	1.33	2	0.01	1	0.01	0	0	3	0.02	0	0	0	0	3	6.25	4	1.06	0	0	0	0

RAW DATA - INSHORE COASTAL STUDY (SECTION III)

CRUISE I

Station	Date	Time	Depth (metre)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	19.8.71	1045	Surface	61.16	1.72	10.5	33.55
		(Day)	10	44.44	0.68	11.00	33.65
			20	45.32	0.11	11.0	33.65
IC2		1315	S	50.38	3.42	10.8	33.55
			10	38.28	5.22	11.0	33.65
			20	44.88	2.51	11.0	33.65
IC3		1500	S	56.98	2.76	11.8	34.20
			10	42.46	7.83	11.8	34.30
			20	51.26	2.58	11.5	34.30
IC1	19.8.71	2020	S	52.80	1.61		
		(Night)	10	43.78	1.76		
			20	51.26	1.66		
IC2		1915	S	56.32	1.33		
			10	43.56	4.48		
			20	45.32	2.98		
IC3		1800	S	33.88	1.99		
			10	33.66	2.90		
			20	40.92	2.20		

CRUISE II

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	16.9.71	1400	S	45.76	1.38	12.0	32.35
			10	40.48	5.43	11.5	32.65
			20	45.32	0.83	11.5	33.20
IC2		1540	S	40.70	4.85	11.5	32.50
			10	40.26	3.04	11.5	33.50
			20	40.04	0.12	11.5	34.85
IC3		1715	S	48.93	4.55	11.0	34.70
			10	51.04	0.49	11.0	34.75
			20	54.34	0.37	11.5	34.80
IC1	21.9.71	1850	S	45.98	8.75		
			10	42.02	6.13		
			20	47.74	2.88		
IC2		2000	S	44.88	3.26		
			10	35.64	10.45		
			20	41.14	15.56		
IC3		2130	S	58.61	15.82		
			10	40.26	1.06		
			20	33.00	6.44		

CRUISE III

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	19.10.71	1010	S	48.84	4.12	12.3	32.55
			10	37.40	1.36	12.0	33.95
			20	46.20	1.95	11.8	35.05
IC2		1130	S	53.68	1.49	12.0	33.40
			10	30.58	0.90	11.8	33.95
			20	48.62	0.41	11.8	35.02
IC 3		1340	S	36.52	2.67	11.9	35.05
			10	27.72	2.54	11.9	35.08
			20	32.78	3.97	12.0	35.10
IC1	19.10.71	2110	S	45.54	3.29		
			10	25.96	3.47		
			20	27.94	2.77		
IC2		1950	S	41.58	2.95		
			10	31.68	1.82		
			20	37.62	2.86		
IC3		1830	S	39.60	3.28		
			10	33.44	2.02		
			20	46.86	1.07		

CRUISE IV

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	26.11.71	0900	S	40.26	2.55	14.2	32.55
			10	26.62	3.57	13.8	32.80
			20	23.10	2.92	13.8	33.35
IC2		1045	S	29.74	0.84	14.2	33.25
			10	24.42	2.66	13.5	33.75
			20	23.98	1.46	13.5	34.10
IC3		1200	S	35.64	0.14	14.5	33.85
			10	29.70	0.59	13.5	34.25
			20	31.68	1.11	13.5	34.25
IC1	29.11.71	2230	S	23.76	9.47		
			10	11.44	11.36		
			20	16.50	19.09		
IC2		2130	S	29.92	21.89		
			10	26.40	12.12		
			20	27.28	7.88		
IC3		2025	S	16.94	23.61		
			10	37.84	10.44		
			20	42.68	16.11		

CRUISE V

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	14.12.71	1330	S	23.76	5.68	16.3	33.19
			10	14.61	13.18	15.1	33.20
			20	12.32	17.25	14.9	33.87
IC2		1215	S	37.97	1.45	15.0	33.18
			10	24.64	90.91	14.5	33.88
			20	22.48	67.62	14.0	34.89
IC3		1030	S	41.36	0.66	15.5	33.58
			10	27.72	8.48	15.0	34.01
			20	27.81	8.45	14.5	34.86
IC1	22.12.71	2240	S	22.00	73.00		
			10	13.64	169.00		
			20	14.08	102.27		
IC2		2135	S	25.56	37.75		
			10	12.41	94.28		
			20	13.64	87.61		
IC3		2010	S	32.56	2.61		
			10	21.78	3.67		
			20	22.44	31.42		

CRUISE VI

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	10.1.72	1430	S	30.58	1.14	18.0	34.17
			10.	27.63	2.08	17.8	34.23
			20	33.35	4.20	17.2	34.44
IC2		1215	S	44.22	1.64	17.5	34.15
			10	20.33	2.34	17.3	34.26
			20	46.20	1.08	16.5	34.85
IC3		1030	S	41.45	2.65	17.5	34.53
			10	23.10	0.87	17.3	34.57
			20	34.76	0.79	17.0	34.64
IC1	14.1.72	2240	S	20.15	5.33		
			10	37.40	6.67		
			20	32.12	13.54		
IC2		2135	S	29.74	8.91		
			10	19.71	7.48		
			20	21.30	6.10		
IC3		2010	S	24.82	58.82		
			10	36.52	51.00		
			20	23.45	15.67		

CRUISE VII

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	21.2.72	0930	S	25.08	0.20	19.2	34.45
			10	24.73	0.61	19.2	34.33
			20	23.85	0.42	18.8	34.23
IC2		1140	S	28.60	0.09	19.5	34.36
			10	20.59	0.12	18.5	34.54
			20	14.96	5.01	18.5	34.75

CRUISE VIII

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	20.3.72	1545	S	20.24	0.12	17.0	34.65
			10	20.46	3.91	17.0	34.65
			20	34.32	11.66	17.0	34.62
IC2		1650	S	24.86	0.10	17.0	34.4
			10	24.64	3.15	17.0	34.49
			20	21.56	3.71	17.0	34.54
IC3		1830	S	25.78	0.97	17.0	34.53
			10	20.24	2.84	17.0	34.50
			20	14.08	2.84	17.0	34.72
IC1	20.3.72	2130	S	30.36	4.86		
			10	25.08	7.18		
			20	24.29	4.73		
IC2		2015	S	26.40	6.82		
			10	20.33	8.86		
			20	19.89	7.67		
IC3		1900	S	29.57	2.79		
			10	10.34	7.98		
			20	19.45	6.17		

CRUISE IX

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	20.4.72	1420	S	38.28	1.11	15.50	34.43
			10	30.10	6.65	15.5	34.47
			20	27.72	9.02	15.5	34.58
IC2		1530	S	28.51	0.88	16.0	34.28
			10	18.92	1.85	16.3	34.69
			20	25.30	4.64	16.5	35.19
IC3		1635	S	26.62	2.91	16.0	35.52
			10	25.17	7.75	16.0	35.57
			20	23.98	7.92	16.0	35.63
IC1	20.4.72	2020	S	25.30	1.19		
			10	22.44	2.23		
			20	33.35	1.12		
IC2		1915	S	23.54	2.97		
			10	26.18	9.17		
			20	32.56	8.29		
IC3		1810	S	20.24	3.85		
			10	23.89	5.44		
			20	31.24	12.24		

CRUISE X

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (°C)	Salinity (‰)
IC1	25.5.72	1330	S	33.66	5.79	12.8	34.07
			10	36.74	11.36	12.8	34.22
			20	29.74	2.86	13.0	34.32
IC2		1440	S	40.92	3.42	13.0	34.39
			10	19.36	2.07	13.3	34.53
			20	31.50	1.59	13.5	34.81
IC3		1550	S	44.88	7.97	13.0	34.35
			10	43.21	7.29	13.3	34.62
			20	41.80	8.91	13.6	34.90
IC1		1950	S	44.00	3.64		
			10	33.00	6.36		
			20	31.24	5.20		
IC2		1850	S	37.80	4.37		
			10	28.07	12.56		
			20	25.30	5.53		
IC3		1730	S	42.06	3.74		
			10	27.63	20.36		
			20	24.64	14.51		

CRUISE XI

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	15.6.72	1415	S	69.96	4.23	12.3	32.84
			10	47.74	5.08	12.0	33.57
			20	64.46	1.55	12.2	34.02
IC2		1525	S	67.67	2.59	12.0	33.34
			10	72.16	3.05	12.0	33.93
			20	55.35	2.17	12.3	34.79
IC3		1635	S	66.97	6.87	12.3	34.12
			10	43.78	3.31	12.3	34.41
			20	49.28	6.29	12.8	34.73
IC1		2005	S	54.34	2.58		
			10	43.12	2.55		
			20	58.96	2.97		
IC2		1850	S	66.00	6.52		
			10	51.48	9.76		
			20	41.80	6.69		
IC3		1740	S	57.86	15.25		
			10	48.18	9.96		
			20	36.52	3.77		

CRUISE XII

Station	Date	Time	Depth (m)	Water Filtered (m^3)	Biomass ($ml/100m^3$)	Temp. (^oC)	Salinity (‰)
IC1	25.8.72	1345	S	55.00	1.18	9.8	32.89
			10	34.76	0.14	9.8	32.94
			20	52.14	0.14	9.9	33.09
IC2		1455	S	51.92	0.72	10.2	32.76
			10	30.36	0.25	10.3	33.35
			20	50.16	1.35	11.2	34.67
IC3		1615	S	70.62	7.43	10.6	33.93
			10	42.90	4.66	11.1	34.54
			20	34.76	4.32	11.2	34.80
IC1		2015	S	53.68	2.05		
			10	21.21	0.71		
			20	44.88	2.34		
IC2		1830	S	9.68	0.77		
			10	8.80	7.39		
			20	7.92	6.94		
IC3		1730	S	35.20	1.63		
			10	24.38	6.97		
			20	31.28	7.67		

August 1971 CRUISE I	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	1.18	-	-	131.63	-	-	568.28	-	-	1903.76	-	-	637.00	-	-	14.23	-	-
*A. clausi	495.48	-	-	118.75	-	-	39.38	-	-	22.91	-	-	8.01	-	-	1.06	-	-
G. inermis	0.33	-	-	27.3	-	-	2.6	-	-	252.1	-	-	0	-	-	11.8	-	-
G. pectinatus	0	-	-	0.2	-	-	0	-	-	0.4	-	-	0	-	-	0	-	-
E. acutifrons	0	-	-	0.38	-	-	0	-	-	2.1	-	-	0	-	-	0	-	-
C. australis	0.82	0.68	0.44	0.76	1.14	0.39	0.99	1.82	2.01	5.33	0	1.53	1.40	1.18	0.58	0	2.67	2.93
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.49	0.99
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0.45	0	0.38	0	0.78	0	0	0	0	0	0.22	2.46	0	0.20	1.18	1.19	1.47
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0.22	0	0	0	0	0	0	0	0	0	0.89	0	0

CRUISE I	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0.20	0	0	0.18	0.23	0	0	0.24	0	0.30	0	0.24
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0	0	0	0.59	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.30	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0	0	0	0.59	0	0.52	1.56	0.89	7.12	4.85	0.35	0.47	0.59	0	0.89	2.44
P. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0.22	0.53	0.23	0.22	0.70	1.88	0.78	0	0.89	0.73
C. australiensis	63.28	29.25	17.87	26.67	38.37	37.66	45.06	28.47	19.61	14.92	11.48	14.34	1.23	0	0	0	0.60	0
C. bradyi	0	0	0	0	0	0	0	0	0.22	0.84	0.92	0	0.18	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE I	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0	1.71	0	0	0	0	0	1.07	0	0.44	0	0	0	0	0	0.98
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0.33	0.68	0.88	1.14	0.46	0.59	0.40	0	2.01	1.18	5.28	2.43	1.76	1.88	1.57	1.18	3.86	7.58
EUPHAUSIACEA																		
Ny. australis	0	0	0	0	0	0	0	0	0	0.53	0	0	0	0	0	0.30	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	0	0.23	0.59	0	0	0	0.89	0.69	0	0	0	0	0	1.79	0
S. minima	0.33	0.68	0	0	9.60	1.76	0	0.52	0.22	2.13	0.46	1.32	1.41	9.18	15.61	1.78	38.92	33.22
S. guileri	0	0	0	1.90	0.92	0.39	0	0	0.87	12.22	0.23	0	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The numbers in No. per 10 cubic metres;
* - No. per cubic metre.
(S = Surface; M = 10m; B = 20m)

September, 1971 CRUISE II	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	38.81	-	-	2905.13	-	-	432.90	-	-	617.11	-	-	388.31	-	-	1568.33	-	-
*A. clausi	321.71	-	-	572.55	-	-	56.39	-	-	79.86	-	-	177.40	-	-	333.05	-	-
G. inermis	0	-	-	5.7	-	-	5.2	-	-	166.7	-	-	0	-	-	10.2	-	-
G. pectinatus	0	-	-	0.4	-	-	0	-	-	0	-	-	0	-	-	0	-	-
E. acutifrons	0.66	-	-	13.1	-	-	4.7	-	-	114.1	-	-	0	-	-	3.41	-	-
C. australis	0	0	0	5.66	2.38	1.89	4.18	0	0	28.97	4.77	7.58	17.78	0.78	0	21.50	5.46	27.27
N. tonsus (Cp)	0	0	0	0	0	0	0	0.99	0	1.12	1.96	0.49	0	0.78	0.18	0	2.98	4.85
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE II	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	2.43	2.86	0	0.37	0	0.39	0.91
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0.97	7.97	0	0	0	0.50	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0.73	1.23	0	0	0	0	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0.72	0	0.22	0	0.42	0	1.49	0.50	2.23	1.40	2.43	1.02	0	0.37	0.34	0.50	1.82
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18	0	0	0.30
C. australiensis	147.95	60.52	40.82	51.76	80.91	48.18	58.23	15.40	5.25	144.48	42.09	88.72	22.07	0.59	0.55	891.32	20.37	20.61
C. bradyi	0	0	0	0	0	0	0	0.25	0	0.45	0	0.24	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.30

CRUISE II	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0	0	0.71	0	0	0	0	1.11	0.28	0	0	0	0.37	2.73	0.25	0.91
O. venusta	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0.20	0	0	0	0
O. media	0.44	0.99	0.89	0.22	0	0.42	5.65	3.23	0.50	0.45	0.84	1.46	3.27	3.53	0.55	1.02	1.49	13.03
EUPHAUSIACEA																		
Ny. australis	0	0	0	0.22	0	0	0	0	0	0	0	0	0	0	0	3.07	0	4.85
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	1.96	0	0.21	0.25	0	0	0	0.25	0	0	0.39	0.18	1.02	0.50	3.94
S. minima	0	0	0.88	0	0	0	0.98	0.25	0.25	0.45	140	0.73	0	0	0	0	0.25	3.33
S. gurleri	0	0	0	0.22	0	0	0	0	0	6.91	1.40	1.95	0	0	0	0	0.25	2.13
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

October 1971 CRUISE III	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	39.15	-	-	120.11	-	-	150.22	-	-	338.79	-	-	160.79	-	-	350.50	-	-
*A. clausi	551.68	-	-	176.55	-	-	61.14	-	-	69.65	-	-	120.92	-	-	305.05	-	-
G. inermis	0	-	-	15.8	-	-	3.9	-	-	396.3	-	-	1.1	-	-	20.2	-	-
G. pectinatus	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
E. acutifrons	2.87	-	-	4.4	-	-	4.84	-	-	130.8	-	-	2.5	-	-	55.56	-	-
C. australis	17.82	32.62	38.48	89.59	20.03	2.14	2.42	1.96	2.67	6.25	3.16	7.18	33.96	48.71	170.20	18.44	11.07	29.67
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0.41	0.48	1.89	3.21	0	11.18	8.24	8.08	4.78	4.90
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0.19	0.98	1.65	1.68	1.26	0.80	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0.63	0.53	0.58	0.36	0.31	0.25	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE III	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	0	102.01	0	0	0.25	0.30	0
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	1.34	1.52	4.61	1.54	0.72	0.37	0	0.41	4.09	1.26	0.80	3.56	0.72	1.53	2.78	1.50	0.43
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	506.76	3.48	95.24	32.92	35.82	11.87	18.63	3.60	7.82	42.33	6.00	12.49	116.65	41.85	54.61	34.34	3.29	3.63
C. bradyi	0	0	0.43	0.22	0	0	0	0	0	0.96	0.63	0.53	0.58	0.72	1.53	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE III	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0.21	0	0	0.66	0	0	0	0	0	0	0	0	0	0	0.31	3.54	0	0.43
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0.21	0.27	2.81	0.88	0	1.07	0.75	0.98	2.06	2.89	4.10	3.46	0	1.08	1.77	2.02	4.49	1.92
EUPHAUSIACEA																		
Ny. australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0.22	0.66	0	0	0	0	0	0	0	0	0.27	0.36	0.31	5.56	3.29	0
S. minima	0	0.80	1.08	0.44	0.39	0	0	0	0	0.24	0	0	0	0	0.31	0	0	0
S. guileri	0	0	0	2.64	0.77	0.72	0	0	0.21	4.33	0.32	0.27	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

November 1971 CRUISE IV	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	32648	-	-	731.1	-	-	131.41	-	-	89440	-	-	1.12	-	-	19244	-	-
*A. clausi	9727	-	-	120.37	-	-	18.56	-	-	9.36	-	-	0.67	-	-	847.11	-	-
G. inermis	0	-	-	513.5	-	-	0	-	-	0	-	-	0	-	-	27.2	-	-
G. pectinatus	0	-	-	37.9	-	-	0	-	-	0	-	-	0	-	-	0	-	-
E. acutifrons	1.5	-	-	117.9	-	-	2.0	-	-	12.0	-	-	0	-	-	7.1	-	-
C. australis	1.74	0	0	19.79	18.36	16.97	2.35	0.83	0.83	25.41	28.04	6.23	0	0.34	0	40.14	45.19	39.36
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.13	2.90	7.03
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32	C	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE IV	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0.38	0	0.28	0	0	16.53	7.40	1.41
C. mastigo-phorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0	0.84	3.50	0	1.68	0.41	0.83	6.02	10.99	2.20	0	0	0	2.95	2.64	4.92
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdomina-lis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australien-sis	10.20	124	12.99	303.03	123.25	162.42	6.39	123	0	11.03	3.03	2.20	0	0.67	0	599.77	156.71	19.21
C. bradyi	0	0	0	0	0	0	0	0.41	0	0	0.38	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE IV	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0.87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0.65	0	0	14.20	10.49	5.46	0.34	0	0	0.33	0.76	0	0	0	0	14.17	3.96	0
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0.43	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0	0
EUPHAUSIACEA																		
Ny. australis	0	0	0	2.10	2.62	2.42	0	0	0	0	0	0.73	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	1.26	0.87	3.03	0	0	0	0	0	0	0	0	0	0	0	0
S. minima	0.25	0	0	0	0	0.01	0	0	0	0	0.38	0	0	0	0	0	0	0
S. guileri	0	0.87	0.86	284.51	158.22	150.91	0	0	0	2.68	4.93	0.47	0	0	0	0.59	0.53	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

December 1971 CRUISE V	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	558.17	.	.	1054.6	.	.	111.67	.	.	2275.4	.	.	14.30	.	.	170.5	.	.
*A. clausi	86.53	.	.	62.27	.	.	3.80	.	.	125.20	.	.	15.57	.	.	30.41	.	.
G. inermis	0.8	.	.	324.3	.	.	0	.	.	0	.	.	0	.	.	0	.	.
G. pectinatus	2.5	.	.	8.6	.	.	0	.	.	0	.	.	0	.	.	0	.	.
E. acutifrons	5.5	.	.	0	.	.	0	.	.	0	.	.	0	.	.	0	.	.
C. australis	1.68	10.95	4.87	48.63	66.72	105.82	3.42	62.10	66.72	422.14	115.23	42.52	0	19.85	78.03	19.97	56.94	30.53
N. tonsus (C_5)	0	2.74	5.68	1.26	0.73	2.84	0.79	36.06	30.25	7.04	53.19	18.77	0.24	12.62	53.58	13.21	36.57	83.78
K. tenuicornis	0	0	0	0	0	0	0	0	0	1.17	5.64	3.67	0	0.36	0	0	0	1.44
C. carinatus	0	0	0	0	0.73	0.71	0	0	0	2.35	1.61	0.73	0	0	0	1.54	5.51	1.3[illegible]
M. clausi	0.24	0	0	0.46	0	0	0	0.41	0.45	0	0	0	0	0.36	0	0.61	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. stylirem[illegible]s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. [illegible]aris	0	0	0	0	0	0.71	0	0	0	0	0	0	0	0	0	0.31	0	0

CRUISE V	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0.81	0	0	0	1.47	0	1.80	0	0.31	0	0
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0.41	0	0	0	0	0	3.25	0	1.54	0.46	1.34
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	1.37	22.73	2.73	3.67	2.13	0	1.22	0.89	0.78	14.50	4.40	0	0.72	0	0.92	0.92	1.78
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	193.18	75.98	41.40	8.64	4.40	14.21	5.27	18.91	14.32	4.30	10.48	11.73	1.21	0.36	0.36	2.15	0	0.89
C. bradyi	0	0	0	0	0	0	0	0	0	0.39	0	0.73	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE V	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	1.27	0	0	5.00	2.20	3.55	0.53	1.62	1.34	1.57	2.42	0.73	0	0	0.36	1.54	0.92	0.89
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0	0	0	0	0	0	0	1.61	0	0	0	0	0.36	0	0
EUPHAUSIACEA																		
Ny. australis	0	0	0	0.46	0	0.68	0	0	0	0.39	66.72	50.59	0.24	0	0	0.31	0	0
CHAETOGNATHA																		
Sagitta c. tasmanica	0	0	0	4.55	8.80	19.88	0	0	0	37.30	1.61	0	0	0	0	13.26	14.23	29.86
S. minima	0	0	0	0	0.73	0	0	0.41	0	0	0	1.47	0	0	0	0	0.46	0.89
S. guileri	0	0	0	150.84	129.50	239.30	0	0.82	0.89	32.47	1.61	16.86	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

January, 1972 CRUISE VI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	10.73	-	-	369.73	-	-	5.52	-	-	405.5	-	-	0.77	-	-	391.22	-	-
*A. clausi	17.79	-	-	3.97	-	-	0.81	-	-	32.95	-	-	13.51	-	-	29.01	-	-
G. inermis	0	-	-	0	-	-	0	-	-	0.7	-	-	0	-	-	0	-	-
G. pectinatus	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
E. acutifrons	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
C. australis	0	1.08	4.20	17.87	17.93	16.82	1.36	0.49	1.09	38.34	71.04	26.76	0.24	1.30	1.73	103.55	111.93	32.41
N. tonsus (Cp)	0.33	1.81	3.0	1.99	0	0	0.45	3.94	9.09	192.68	8.63	0.47	93.85	17.32	8.34	400.29	339.06	73.81
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.37	0.85
M. clausi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE VI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	0	0.24	0	0	0	0	0
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	0	0	0	0.99	2.72	13.08	0	0	0	1.01	0	0.94	0	0	0	0	0.55	0
C. bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE VI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0	0.52	0.27	0.62	0	0	0	0.67	1.02	0	0.24	0	0	0.42	0	0
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0.50	0	0.62	0	0	0	0	0	0	0	0	0	0	0	0
EUPHAUSIACEA																		
Ny. australis	0	0	0.30	1.99	14.44	6.23	1.36	3.94	0.65	1.01	1.52	4.70	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	0	0.54	0	0	0.49	0.22	6.73	1.01	0	0	1.73	1.44	74.14	109.26	41.36
S. minima	0	0	0	0	0	0	0	0	0.22	0.34	0.51	0	0	0	0	0	0	0
S. guileri	0	0	0	0	0.99	1.07	0	0	0	18.36	37.54	8.92	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise 1.

February, 1972	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
CRUISE VII	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	16.94	.	.	.	.	.	9.26	.	.	.	.	.	.	.	.	.	.	.
*A. clausi	0.1	.	.	.	.	.	1.36	.	.	.	.	.	.	.	.	.	.	.
G. inermis	0	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.
G. pectinatus	0	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.
E. acutifrons	0.4	.	.	.	.	.	3.15	.	.	.	.	.	.	.	.	.	.	.
C. australis	0.83	0.42	2.94	.	.	.	1.40	4.37	2.68	.	.	.	.	.	.	.	.	.
K. tonsus (Cp)	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
H. tenuicornis	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
C. carinatus	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
K. clausi	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
L. plumulosus	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
C. stylirensis	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.
C. tenuis	0	0	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.

CRUISE VII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. mastigophorus	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. arcuicornis	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. parapergens	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. jobci	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
Ct. vanus	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
Pl. gracilis	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
Pl. abdominalis	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
A. danae	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. australiensis	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. bradyi	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
C. bipinnata	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-

CRUISE VII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
L. tasmanica	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
O. venusta	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
O. media	0	0	0	-	-	-	1.21	0.49	0	-	-	-	-	-	-	-	-	-
EUPHAUSIACEA																		
Ny. australis	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
S. minima	0	0	0	-	-	-	0	0.49	0	-	-	-	-	-	-	-	-	-
S. guileri	0	0	0	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-
PELAGIC TUNICATA																		
S. fusiformis	0	0.40	96.02	-	-	-	0	16.22	223.96	-	-	-	-	-	-	-	-	-

Legion as in Cruise I.

March, 1972 CRUISE VIII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	4.50	-	-	73.12	-	-	18.75	-	-	76.14	-	-	328.94	-	-	173.83	-	-
*A. clausi	1.58	-	-	16.8	-	-	2.01	-	-	1.14	-	-	3.57	-	-	14.88	-	-
G. inermis	0	-	-	5.3	-	-	0.4	-	-	3.8	-	-	0	-	-	0	-	-
G. pectinatus	0	-	-	0	-	-	0	-	-	0.8	-	-	0	-	-	0	-	-
E. acutifrons	4.94	-	-	6.36	-	-	4.83	-	-	7.96	-	-	0	-	-	0	-	-
C. australis	0	1.47	14.57	97.83	23.65	157.68	0.40	8.12	8.35	9.85	2.95	2.51	6.64	3.95	2.84	29.42	14.75	29.01
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0.39	0	0	0	0	0

CRUISE VIII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. mastigo-phorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0	0	0	0	0	0.81	0.46	0.76	0	0	0	0	0	0.34	0	0.51
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdomina-lis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australien-sis	1.98	3.91	6.41	3689	3.10	25.53	1.61	1.62	0.92	2.65	0.49	0.50	1.55	0	0	4.06	0	0
C. bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE VIII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0.33	0	0	2.64	1.59	0.41	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0.29	2.31	1.20	0	0	0	0	0.76	0	0	0	0	0	0.34	0	0
C. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0.24	2.64	0	0	0	0	0.46	0	0	1.01	0	0	0	0	0	0
EUPHAUSIACEA																		
Ny. australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	0.33	0	0	0	0	0.46	0	0	0	0	0	0	3.04	1164	2.57
S. minima	0	0.49	0	0	0	0	0	0	0.93	0	0	0	0	0	0.71	0	0	0
S. guileri	0	0	0	0.33	0	0	0	0	0	0.38	0	1.51	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	3.95	0	0	0	1.03

Legion as in Cruise I.

April, 1972 CRUISE IX	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	108.42	-	-	57.71	-	-	10.31	-	-	44.61	-	-	146.5	-	-	53.5	-	-
*A. clausi	4.20	-	-	0.16	-	-	0.21	-	-	0.98	-	-	0.30	-	-	0.59	-	-
G. inermis	0	-	-	0.8	-	-	0.7	-	-	0	-	-	0	-	-	0	-	-
G. pectinatus	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
E. acutifrons	6.8	-	-	6.32	-	-	1.4	-	-	22.1	-	-	0	-	-	0	-	-
C. australis	0	1.99	21.08	4.74	3.56	2.4	1.43	4.23	5.34	4.24	11.84	7.07	2.63	4.76	6.68	7.9	32.88	19.1
K. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0	0	1.60
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. clausi	0	0	0	0	0	0	0.35	0.53	0.40	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0.49	0	0.64
C. stylirenis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0.38	0.31	0	0	0.83	0.99	1.26	0.32

CRUISE IX	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0.70	0.53	0	0	0.38	0.31	1.88	1.59	2.50	5.43	6.28	3.20
C. mastigo-phorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. arcuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.42	0	0.42	0
C. parapergens	0	0	0	0.40	0	0	0	0	0	0	0.53	0	0.99	0.79	2.09	0.68	0.42	1.60
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0.36	0	0.45	0.60	0	0.53	0	1.27	3.06	2.76	0.38	2.38	0.83	1.48	0.89	1.60
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pl. abdomina-lis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32
A. danae	0	0	0	0	0	0	0.35	0	0.79	0.42	0.38	0.61	1.13	5.56	8.34	2.47	3.35	2.88
C. australien-sis	5.23	3.32	25.61	17.39	43.67	18.29	1.43	0	1.19	5.10	8.40	4.30	4.51	3.58	0	6.92	3.77	1.60
C. bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE IX	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0.33	6.85	1.56	2.03	2.10	0.35	0	0.79	0	0.76	0	0	0	0	0	0	0.64
C. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0.36	0	0	0	0	0.53	0.40	0	0.38	0.31	0	0.42	0.42	0	0	0.64
<u>EUPHAUSIACEA</u>																		
Ny. australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>CHAETOGNATHA</u>																		
Sagitta s. tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. minima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.25	0	0	0.32
S. guileri	0	0	0	1.58	1.78	1.20	0	0	0	1.27	0	0	0	0	0	0	0	0
<u>PELAGIC TUNICATA</u>																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

May, 1972 CRUISE X	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	120.25	-	-	550.91	-	-	830.50	-	-	936.51	-	-	464.17	-	-	82.50	-	-
*A. clausi	131.67	-	-	5.46	-	-	6.06	-	-	3.44	-	-	5.59	-	-	0.19	-	-
G. inermis	4.8	-	-	33.2	-	-	0	-	-	0.53	-	-	0	-	-	1.43	-	-
G. pectinatus	0	-	-	3.2	-	-	0	-	-	0.26	-	-	0	-	-	0	-	-
E. acutifrons	8.02	-	-	38.63	-	-	19.1	-	-	277.8	-	-	3.99	-	-	5.23	-	-
C. australis	0.89	2.72	2.02	9.55	8.18	18.89	0.98	3.10	0.52	5.56	6.77	8.70	16.27	34.25	51.95	8.56	7.60	50.76
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0.40	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.24	0	0
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE X	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0.93	3.11	0.71	1.45	0.41
C. mastigo-phorus	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.23	0	0.48	0.36	0.41
C. arcuicornis	0	0	0	0	0	0	0	0	0.63	0	0	0.40	0.89	1.16	1.44	6.42	9.41	0.41
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.48	0.36	2.03
Ct. vanus	0	0.54	0.67	1.36	1.21	1.60	0.49	1.03	0	0.26	0.36	0.40	0.67	0.46	0.24	0	0.36	2.44
Pl. gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.36	1.22
Pl. abdomina-lis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0.23	0	0	0	0
C. australien-sis	291.15	149.70	34.30	190.68	51.82	381.24	45.70	12.91	7.30	38.42	19.95	25.69	16.27	33.79	13.40	33.76	14.84	2.44
C. bradyi	0	0	0	0	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE X	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0.23	2.42	1.60	0	0	0	0.26	0	0	0	0	0	0	0	0
L. tasmanica	0.30	0	0	6.36	11.51	13.44	1.22	0	0	1.59	0	0	1.78	1.62	1.43	1.43	0.72	1.43
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0	0.61	0	0	0	0	0	1.07	0	0	1.85	1.44	1.24	0.36	2.03
<u>EUPHAUSIACEA</u>																		
Ny. australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>CHAETOGNATHA</u>																		
Sagitta s. tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. minima	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0.48	0	0	0
S. guileri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>PELAGIC TUNICATA</u>																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

June, 1972 CRUISE XI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	117.08	-	-	190.84	-	-	16.12	-	-	854.6	-	-	159.1	-	-	278.16	-	-
*A. clausi	19.21	-	-	1.20	-	-	78.97	-	-	0.76	-	-	7.20	-	-	0.55	-	-
G. inermis	0.43	-	-	31.8	-	-	1.77	-	-	0.76	-	-	1.49	-	-	0.35	-	-
G. pectinatus	3.2	-	-	0.9	-	-	11.6	-	-	0	-	-	0.9	-	-	0	-	-
E. acutifrons	0.57	-	-	8.83	-	-	10.1	-	-	133.3	-	-	4.18	-	-	10.37	-	-
C. australis	0.14	1.26	0.16	5.34	3.71	5.60	2.22	0.14	0.36	19.55	6.41	1.44	0	0	14.61	10.29	30.10	11.23
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. tenuicornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0	0	0
C. tenuis	0	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE XI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0.55
C. mastigophorus	0	0	0	0	0	0	0.44	0	0	0	0	0	0	0	0	0.52	0.21	0.27
C. arcuicornis	0	0	0	0	0	0	0.15	0	0	0	0	0	0	0	0.20	0	0	0.27
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.21	0.27
C. jobei	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0.21	0.55
Ct. vanus	0	0.42	0.47	0	0.46	0.17	0	0	0	0.61	0.97	0	0.90	2.97	1.01	0.52	0.83	1.37
Pl. gracilis	0	0	0	0	0	0	0	0	0	0.15	0	0	0	0	0.20	0.52	0.42	0.55
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	7.00	5.24	0.93	5.89	4.64	12.21	31.62	9.42	4.88	6.67	7.58	4.07	12.24	0.91	3.65	39.23	8.30	7.39
C. bradyi	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0.17	1.04	0.82
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE XI	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0.16	5.70	1.62	0.51	0.15	0	0	0	0	0	0	0	0	0	0	C
L. tasmanica	0	0	0	0.92	0.23	0.17	0.89	0.42	0	1.82	0.39	0	0	0	0.41	3.97	0.62	1.09
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C	0	0
O. media	0	0	0	0.74	0.46	0.34	0.15	0.42	0	0.45	1.17	0	0	0	0	0.17	1.87	1.64
EUPHAUSIACEA																		
Ny. australis	0	0	0	0	0	0.17	C	0	0	0	0	0	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. minima	0.14	0.42	0.62	0.55	0.23	0.51	0	0	0	0	0	0	0	0	0	C	0	0
S. guileri	0	0	0	0.55	0.23	0.17	0	0	0	0	0	0	0	0	0	C	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

July, 1972 CRUISE XII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
*P. parvus	93.10	-	-	162.44	-	-	165.64	-	-	1849	-	-	233.0	-	-	294.0	-	-
*A. clausi	398.98	-	-	29.06	-	-	42.1	-	-	8.78	-	-	6.63	-	-	5.11	-	-
G. inermis	0	-	-	12.11	-	-	0	-	-	439.1	-	-	0	-	-	6.5	-	-
G. pectinatus	0	-	-	0.37	-	-	0	-	-	8.3	-	-	0	-	-	0	-	-
E. acutifrons	0	-	-	0.93	-	-	0.39	-	-	2.07	-	-	0	-	-	0	-	-
C. australis	0	0.29	0.19	0.93	0.47	1.56	0.38	0	0.20	3.10	22.73	5.05	0.28	7.23	5.48	9.94	3.28	8.95
N. tonsus (Cp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. tenuicornis	0	0	0	0	0	0	0	0	0.20	0	0	0	0	0.23	0.58	0	0.82	0.96
C. carinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M. clausi	0	0	0	0	0	0	0	0	0	0	0	0	0	0.47	1.44	0	0	0.52
L. plumulosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. styliremis	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.23	0.29	0	0	0.64
C. tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRUISE XII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
C. ingens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.80	0	0.41	0.96
C. mastigophorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0.47	2.59	0.85	7.79	2.56
C. arcuicornis	0	0	0	0	0	0	0	0	0.40	0	0	0	0	3.03	4.03	1.70	0.82	3.84
C. parapergens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. jobei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ct. vanus	0	0	0.38	0.37	0	0	0	0.66	0	2.07	2.27	0	0	2.80	4.61	0.57	0	7.03
Pl. gracilis	0	0	0	0	0	0	0	0	0	1.03	0	1.26	0	1.63	0.29	1.14	0.82	1.28
Pl. abdominalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. danae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. australiensis	33.45	2.59	3.64	18.66	29.23	60.61	18.88	5.27	7.38	14.46	12.50	11.36	10.48	6.53	10.07	28.13	2.46	7.99
C. bradys	0	0	0	0	0	0	0	0	0	0	0	1.26	0	0.70	1.73	0.28	0	4.16
C. bipinnata	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0	0	0	0

CRUISE XII	Station IC 1						Station IC 2						Station IC 3					
	Day			Night			Day			Night			Day			Night		
	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
P. cornutus	0	0	0	0.56	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0
L. tasmanica	0	0	0	0.19	0	0.22	0.19	0	0	2.07	0	1.26	0.99	0.47	2.30	0.57	0	1.28
O. venusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O. media	0	0	0	0	0	0	0	0	0.20	2.07	0	2.53	0	1.23	1208	1.14	6.97	24.94
EUPHAUSIACEA																		
Ny. australis	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0	0
CHAETOGNATHA																		
Sagitta s. tasmanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0.47	4.03	18.69	4.43	24.30
S. minima	0	0	0	0.19	0	0	0	0	0.20	0	0	0	0	0.70	6.33	0.28	6.56	12.79
S. guileri	0	0	0.76	3.17	1.41	1.56	0	0	0.20	0	0	3.79	0	0	0	0	0	0
PELAGIC TUNICATA																		
S. fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legion as in Cruise I.

(Species occurring only once are not included in this list.)

PERCENTAGE COMPOSITION OF ZOOPLANKTON AT STATION IC2

	August 1971		September		October		November		December	
	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
COPEPODS										
Paracalanus parvus	1236.0	96.30	3425.10	96.90	244.42	71.74	512.90	96.64	1193.5	91.86
Acartia clausi	31.14	2.43	83.12	2.35	65.39	19.20	13.96	2.63	64.50	4.96
Gladioferens inermis	12.74	0.99	8.60	0.24	20.01	5.87	0	0	0	0
Oithona spp.	0.28	0.22	1.02	0.03	0.58	0.17	0.92	0.17	0.63	0.05
Calanus australis	0.32	0.03	1.56	0.05	0.43	0.13	1.39	0.26	21.24	1.64
Centropages australiensis	3.00	0.23	10.15	0.30	3.05	0.90	0.87	0.16	19.38	1.49
Euterpina acutifrons	0.11	0.01	5.94	0.20	6.78	2.0	0.70	0.12	0	0
TOTAL COPEPODS	1283.59		3535.58		340.66		530.94		1299.25	
NON-COPEPODS										
Cladocerans	62.90	75.1	124.58	54.0	2.81	28.09	106.34	58.0	2.55	2.86
Lucifer henseni	0.87	1.04	0.12	0.05	0.01	0.14	0.03	0.02	0	0

January 1972		February		March		April		May		June		July	
No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
205.51	90.53	9.26	80.59	47.44	93.64	27.46	88.04	883.50	95.82	500.34	88.73	92.07	64.43
16.88	7.44	1.38	10.23	1.15	2.24	0.59	1.91	4.75	0.52	39.86	7.10	25.42	17.29
0.02	0.01	0	0	0.21	0.41	0.01	0.03	0.03	0.01	0.13	0.02	21.93	15.10
3.00	1.32	0.49	4.27	0.51	1.01	1.33	4.27	14.31	1.55	13.36	2.37	1.63	1.14
1.56	0.69	0.05	0.44	0.51	1.01	0.28	0.91	0.33	0.04	1.09	0.19	0.17	0.12
0.05	0.02	0	0	0.21	0.41	0.33	1.06	4.26	0.46	1.91	0.34	1.67	1.01
0	0	0.32	2.74	0.64	1.26	1.18	3.77	14.84	1.61	7.17	1.27	0	0
227.02		11.49		50.66		31.19		922.03		563.86		142.90	
0	0	0.73	3.61	3.20	10.23	75.14	76.14	82.18	82.81	9.65	32.93	0.09	2.23
0.31	0.09	0.14	0.69	6.42	20.55	2.20	2.23	0.33	0.34	16.20	55.32	1.86	46.03

PERCENTAGE COMPOSITION OF ZOOPLANKTON AT STATION IC2

	August 1971		September		October		November		December	
	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
Euphausids	18.67	22.50	104.10	45.12	1.48	14.18	2.21	1.20	63.23	71.08
Amphipods	0.07	0.08	0.07	0.03	0.08	0.81	0.39	0.21	0.23	0.26
Decapoda larvae	0.14	0.17	0.33	0.14	0.21	2.09	0.36	0.19	0.61	0.68
Molluscs	0	0	0	0	1.54	15.34	0.44	0.24	0.26	0.29
Fish eggs & larvae	0.35	0.32	0.47	0.21	0.35	3.49	72.90	39.60	18.60	20.91
Appendicularians	0	0	0	0	3.29	32.94	0.47	0.26	0.23	0.26
Other Groups	0.80	0.06	1.05	0.46	0.29	2.88	0.24	0.79	3.25	3.66
TOTAL NON-COPEPOD POPULATION	83.80		230.72		10.06		183.30		88.96	
TOTAL ZOOPLANKTON	1367.39		3766.30		350.72		714.12		1386.2	
% OF COPEPODS	93.87		93.87		97.13		74.32		93.59	

January 1972		February		March		April		May		June		July	
No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
1.85	0.50	0	0	0.23	0.73	0	0	0.24	0.24	2.51	8.56	0.21	5.31
0.35	0.10	0	0	20.08	64.26	2.76	2.80	0.74	0.76	0.72	2.45	0.41	10.59
0.71	0.19	0	0	0.17	0.55	0	0	0.027	0.028	0	0	0.41	10.59
359.34	97.19	12.34	60.67	0.27	0.85	14.13	14.32	13.39	13.49	0.09	0.31	0	0
0.16	0.04	7.13	35.04	0.36	1.15	0	0	0.12	0.12	0.08	0.29	0.04	1.0
0.51	0.14	0	0	0.22	0.7	4.00	4.05	2.04	2.06	0	0	0.21	5.46
6.47	1.75	0	0	0.30	0.97	0.46	0.46	0.16	0.16	0.04	0.13	0.73	18.37
369.70		20.34		31.25		98.69		99.24		29.29		3.90	
596.72		31.83		81.91		129.88		1021.32		593.15		146.8	
38.0[illegible]		36.10		61.85		24.05		90.28		95.06		97.34	

RAW DATA - DERWENT ESTUARY STUDY (SECTION IV)

CRUISE I - 1.10.73

(Fine - patches of cloud)

Station	Time	Depth (m)	Water filtered (m^3)	Temp. °C	Salinity ‰
1	11:05	Surface	19.93	10.20	0
		Bottom		10.20	0
2	10:30	S	21.68	11.00	0
		B		11.20	2.29
3	12:00	S	22.02	11.20	2.89
		B		11.45	9.35
4	12:30	S	10.84	11.20	5.43
		B		11.45	12.40
5	13:10	S	9.76	11.60	11.03
		B		11.80	23.18
6	13:40	Surface	8.13	11.85	15.91
		Mid-water		11.80	32.03
		Bottom		11.85	32.44
7	14:10	S	21.89	12.45	27.86
		M		11.90	32.92
		B		11.90	33.16
8	14:40	S	16.26	12.65	32.52
		M		12.00	34.04
		B		11.90	34.42
9	15:20	S	14.60	12.30	33.02
		M		12.10	33.27
		B		11.85	34.51
10	16:00	S	16.18	12.15	33.91
		M		11.95	34.20
		B		11.90	34.53

CRUISE II - 23.4.74

(Heavily overcast at first, but becoming fine during the day.)

Station	Time	Depth (m)	Water filtered (m^3)	Temp. ^oC	Salinity ‰
1	10:30	Surface	22.10	13.95	0
		Bottom		14.60	0
2	11:05	S	30.02	15.60	2.29
		B		14.95	2.98
3	11:35	S	28.52	15.25	2.58
		B		14.95	9.02
4	12:15	S	30.77	14.95	5.71
		B		15.40	12.75
5	12:50	S	29.61	14.95	13.10
		B		15.40	23.92
6	13:25	Surface	33.57	15.25	16.98
		Mid-water		15.55	33.87
		Bottom		15.65	34.49
7	14:00	S	29.94	15.95	25.79
		M		15.60	34.12
		B		15.60	34.49
8	14:35	S	32.32	15.45	34.31
		M		15.45	34.38
		B		15.45	34.43
9	15:05	S	33.36	15.60	34.03
		M		15.40	34.19
		B		15.40	34.34
10	15:15	S	36.45	15.30	34.56
		M		15.30	34.54
		B		15.30	34.56

Cruise Date CRUISE I 1.10.73	STATIONS 1	2	3	4	5	6	7	8	9	10
Gladioferens pectinatus (ad)	0	6.23	1989.10	2490.77	4889.30	7049.18	30.15	10.64	0.47	0.12
G. pectinatus Copepodites	0	9.69	495.00	765.68	387.45	1357.58	0.96	1.72	0.26	0.12
Sulcanus conflictus (ad)	0	0	20.89	7.10	2.58	22.54	0.27	0	0	0
S. conflictus Copepodites	0	0	5.06	0.18	1.72	3.07	0	0	0	0
Acartia clausi (ad)	0	P	0	0	12.05	36.89	276.38	249.08	56.05	86.53
A. clausi Copepodites	0	0	0	0	23.37	13.32	143.90	150.68	43.01	58.71
Paracalanus parvus (ad)	0	0	0	0	12.30	1465.16	1164.92	2669.13	1339.94	3760.82
P. parvus Copepodites	0	0	0	0	28.29	2218.24	8005.94	3413.28	2479.14	4233.62
Mesoclyclops leuckarti	0.15	0.55	0	0	0	0	0	0	0	0
Boekella triarticulata	3.11	1.21	0	0	0	0	0	0	0	0
Gladioferens spinosus	0	1.20	0.09	0	0	0	0	0	0	0

Cruise Date CRUISE I 1.10.73	STATIONS 1	2	3	4	5	6	7	8	9	10
Gladioferens inermis	0	0	0	0	0.98	0.31	0.32	0.31	0.26	0.06
Euterpina acutifrons	0	0	0	0.09	0	2.15	0.55	0.18	0.26	0.31
Sagitta guileri	0	0	0	0	0	0.31	3.93	3.81	0.16	0.12
Labidocera tasmanica	0	0	0	0	0	0	0	0.24	0	0.18
Centropages australiensis	0	0	0	0	0	0	0.37	1.11	0.58	1.36
Calanus australis	0	0	0	0	0	0	0	0	0	0.31
Mecynocera clausi	0	0	0	0	0	0.10	0.09	0	0	0.06
Oncaea media	0	0	0	0	0	0	0.05	0.06	0	0
Ctenocalanus vanus	0	0	0	0	0	0	0.41	0.37	0.16	0.37
Sagitta minima	0	0	0	0	0.12	0.61	0.14	0	0.05	0.68

The numbers in No. per cubic metre.

Cruise Date CRUISE II 23.4.74	STATIONS 1	2	3	4	5	6	7	8	9	10
Gladioferens pectinatus (ad)	0	0.27	0	10.17	1154340	1188.56	10.75	0.22	0.03	0
G. pectinatus Copepodites	0	2.30	20.34	210.59	3687.94	168.31	4.07	0.25	0	0
Sulcanus conflictus (ad)	0	0.40	3.51	166.07	159.07	43.49	3.41	0	0	0
S. conflictus Copepodi	0	0.17	14.03	807.60	117.53	11.92	0.97	0.03	t0s	0
Acartia clausi (ad)	0	0	0	0	0	0	15.03	0.68	0.06	0.14
A. clausi Copepodites	0	0	0	0	0	0	1.30	0.09	0.03	0.03
Paracalanus parvus (ad)	0	0	0	0	0	27.11	95.52	160.58	26.83	20.00
P. parvus Copepodites	0	0	0	0	0	19.96	31.73	54.76	6.74	2.63
Mesoclyclops leuckarti	0	0	0	0	0	0	0	0	0	0
Boekella triarticulata	0.05	0	0	0	0	0	0	0	0	0
Gladioferens spinosus	0	0.27	1.26	0.06	0	0.06	0	0	0	0

Cruise Date CRUISE II 23.4.74	STATIONS 1	2	3	4	5	6	7	8	9	10
Gladioferens inermis	0	0	0	0	0	0	0	0	0	0
Euterpina acutifrons	0	0	0	0	0	0	0.30	0.30	0	0.08
Sagitta guileri	0	0	0	0	0	0	0	0	0	0
Labidocera tasmanica	0	0	0	0	0	0	0	0	0	0
Centropages australiensis	0	0	0	0	0	0	0	0	0.03	0.08
Calanus australis	0	0	0	0	0	0	0	0	0	0
Mecynocera clausi	0	0	0	0	0	0	0	0	0	0.05
Oncaea media	0	0	0	0	0	0	0.03	0	0	0.05
Ctenocalanus vanus	0	0	0	0	0	0	0	0	0	0.03
Sagitta minima	0	0	0	0	0	0	0.23	0.09	0.03	0.16

APPENDIX II

Supporting Paper No. 1

A New Species of *Labidocera* (Copepoda:Calanoida) from Tasmania and its Postnaupliar Developmental Stages.

Aust. J. mar. Freshwat. Res., 1974, 25: 261-272

Aust. J. mar. Freshwat. Res., 1974, **25**, 261–72

A New Species of *Labidocera* (Copepoda: Calanoida) from Tasmania and its Postnaupliar Developmental Stages

Nyan Taw

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Abstract

A new species of genus *Labidocera*, *L. tasmanica* sp. nov., found in the south-east inshore coastal waters of Tasmania, is described and figured. Its postnaupliar developmental stages are described and figured from the samples collected in the northern parts of D'Entrecastreaux Channel, Tasmania.

Introduction

A study of the zooplankton of the inshore coastal waters of the south-east of Tasmania (Storm Bay, mouth of River Derwent and northern part of D'Entrecastreaux Channel) revealed a new species of genus *Labidocera*. It was the only species of the genus so far found and was encountered in almost all the samples collected during a period of 12 months (August 1971 to July 1972). The numbers collected were small, a maximum of 38 adult specimens—30 males and eight females—(14 per 10 m^3) being captured off Barnes Bay, Bruny Island, northern part of D'Entrecastreaux Channel, during a surface night plankton tow on 29 November 1971.

Postnaupliar developmental stages were also found among the samples collected. A maximum concentration was observed during the May samples.

The area under study had the salinity range of $32 \cdot 65$–$35 \cdot 63‰$ and the temperature range was from $9 \cdot 8$ to $19 \cdot 5$°C.

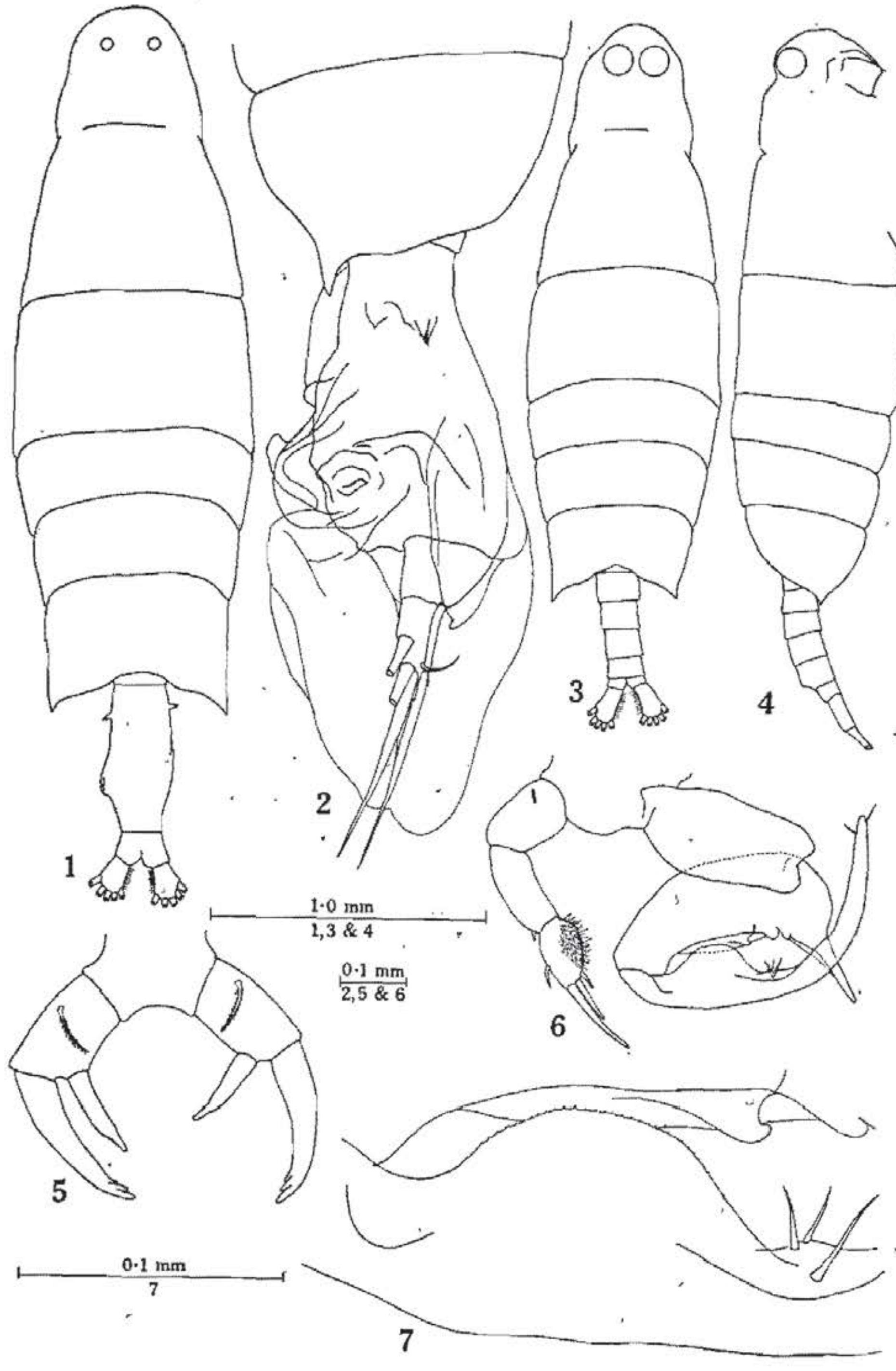
Materials and Methods

Copepodid stages II to V were selected from a mid-water (10 m) plankton tow collected during the night off Barnes Bay. Copepodid stage I was obtained from a surface plankton tow collected during the day at the mouth of the River Derwent. Both collections were made on 25 May 1972. A number of adults—six females and five males at Barnes Bay; one female and two males at the mouth of River Derwent—were also captured in these samples.

The collections were made from the Zoology Department Research Vessel *Neotrigonia* using a simple closing conical plankton net which had the rim area of $0 \cdot 25$ m^2. The mesh size of the net was 200 μm.

The animals were cleared and dissected in a 1 : 2 glycine–water medium with a pair of 'Minutien' insect pins. The dissected parts were mounted in polyvinyl alcohol mounting fluid for detailed microscopic study. The drawings were made with the aid of a camera lucida.

The length was measured from the anterior margin of the cephalic region to the posterior margin of furcal rami from lateral view with 32× magnification power.



Figs. 1–7. *Labidocera tasmanica* sp. nov. 1, Matured female, dorsal view; 2, matured female, last metasomal segment and urosome lateral view; 3, matured male, dorsal view; 4, matured male, lateral view; 5, female fifth leg, posterior aspect; 6, male fifth leg, posterior aspect; 7, proximal expansion of distal segment of male right fifth leg.

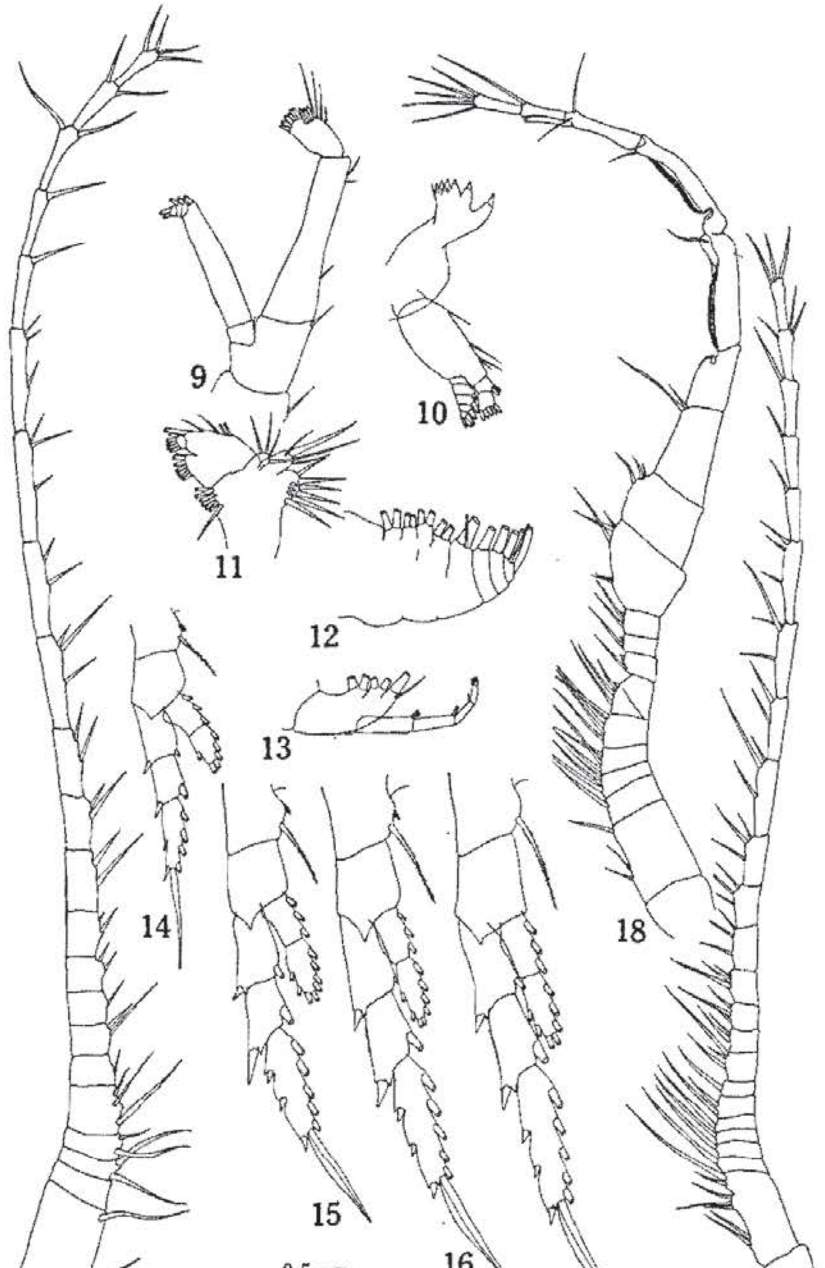
Description

Labidocera tasmanica sp. nov.
(Figs 1–19)

Type Material

Holotype female, allotype male, paratypes 4 females, 4 males; Tasmanian Museum Registration Nos. G 1539–1542. Taken in a mid-water (10 m) plankton tow.

Paratypes 6 females, 2 males; National Museum of Victoria Registration Nos. J 256–J 263. Taken in a surface water plankton tow.



Figs. 8–19. *Labidocera tasmanica* sp. nov. 8, Female antennule; 9, female antenna; 10, female mandible and palp; 11, female 1st maxilla; 12, female 2nd maxilla; 13, female maxilliped; 14, female 1st swimming leg; 15, female 2nd swimming leg; 16, female 3rd swimming leg; 17, female 4th swimming leg; 18, male grasping right antennule; 19, male left antennule.

Paratypes 5 females, 2 males; Australian Museum Registration No. P 19647. Taken in a bottom (20 m) water plankton tow.

All the types were taken during the night on 25 May 1972, off Barnes Bay, Bruny Island, D'Entrecastreaux Channel, Tasmania.

Description of Female

Size, 2·63–3·35 mm (range); 2·83 mm (mean) based on 11 specimens.

Rostrum long and pronounced. First metasomal segment without lateral spines; incompletely divided into cephalic and a post-cephalic portion. Fourth and fifth metasomal segments fused; posterior portion symmetrical from dorsal aspect and projecting as a sharp point.

Urosome asymmetrical and of 2 segments. Genital segment large, swollen ventrally; more than twice as long as its width from dorsal view. Genital aperture situated at the lateral ventroposterior region of the swelling, a small triangular process on each side of the genital segment, situated at the middle lateral part of the anterior half of the segment, the right process being a little more anterior than the left. Anal segment about as long as wide. Furcal rami symmetrical with fine bristles on inner edge of the rami.

Antennule 23-segmented, reaching at least to the posterior margin of the genital segment.

Antenna, mandible, 1st maxilla, 2nd maxilla, maxilliped and 1st to 4th swimming legs similar in structure to the other members of this genus.

Fifth legs biramous. Endopod without any spines or processes; long and slender, at least 3·5 times as long as its maximum width; distal portion narrower, ending as a blunt slightly curved point.

Exopod long and slender; longer than endopod, ending in the form of a blunt fork which has three processes at the inner region directed inwards.

Description of Male

Size 2·45–2·83 mm (range); 2·63 (mean); based on 12 specimens

Metasome similar to that of the female, but dorsal cuticular lenses larger.

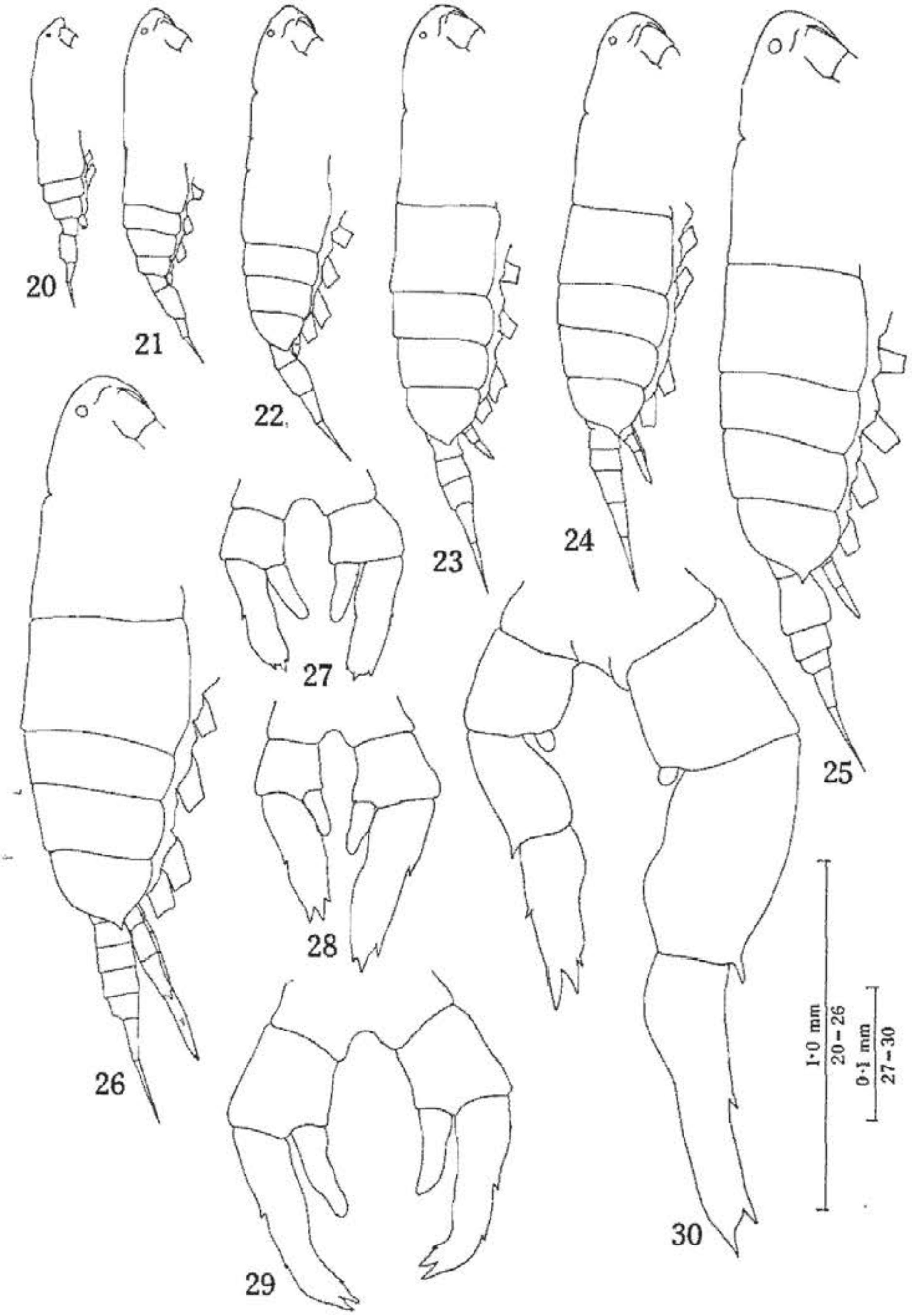
Urosome 5-segmented and symmetrical. Anal segment shorter than its width. Furcal rami symmetrical and twice as long as wide with fine bristles on the inner edge of the rami.

Left antennule 24-segmented. Geniculate right antennule 19-segmented; small denticles on the distal inner edge of segment 14; closely spaced denticles on segment 15, arranged on the inner proximal portion, the distal end being devoid of denticles. Middle inner edge of segment 16 with closely spaced denticles, smaller than those on the preceding segment. 17th segment produced distally into a finger-like process nearly as long as segment 18.

Antenna, mandible, 1st maxilla, 2nd maxilla, maxilliped and 1st to 4th swimming legs similar to female and to rest of genus.

Fifth legs uniramous; left leg 3-segmented, smaller and shorter than right leg; no processes on 1st segment but a small spine on the distal outer part of the 2nd. Distal segment with 4 spines—one large long spine longer than distal segment at the distal apex; two shorter spines on the inner edge of the distal portion, the inner being shorter than the outer; a small narrow spine on the outer margin of the distal segment. A bunch of fine bristles on the inner region of the distal segment.

Right leg subchelate and 3-segmented; middle segment large, broad and produced into a stout spine arising from proximal region. Distal segment long, broad proximally with a serrated edge on the expansion, produced into a blunt apex. Three small setae in the middle inner region of this segment and a seta at the distal inner edge as well as one at distal outer margin.

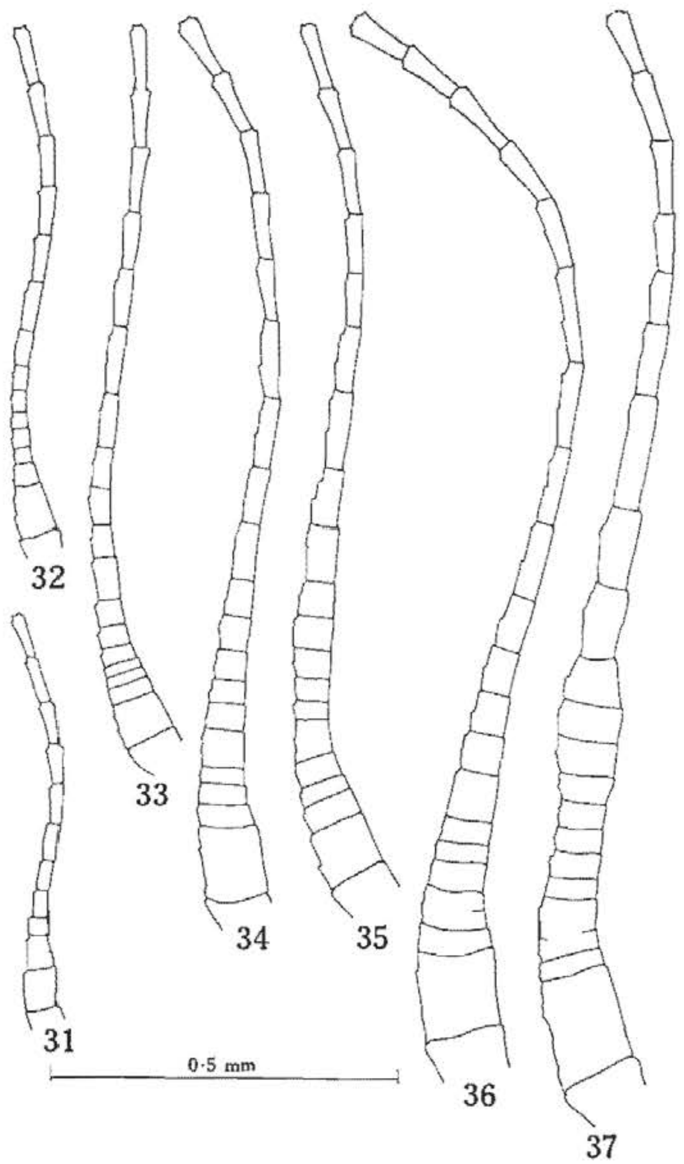


Figs. 20–30. Postnaupliar developmental stages of *L. tasmanica* sp. nov. 20, Copepodid stage I; 21, copepodid stage II; 22, copepodid stage III; 23, copepodid stage IV, female; 24, copepodid stage IV, male; 25, copepodid stage V, female; 26, copepodid stage V, male; 27, female fifth legs, copepodid stage IV; 28, male fifth legs, copepodid stage IV; 29, female fifth legs, copepodid stage V; 30, male fifth legs, copepodid stage V.

Description of Postnaupliar Developmental Stages

(Copepodid Stage I—Figs 20, 31, 38, 43, 48, 53, 58, 63 and 68)

Body length between 0·78 and 0·79 mm (based on 3 specimens). Sexes indistinguishable. Rostrum typical of the later stages lacking. Dorsal cuticular lenses indistinctly developed. Metasome 3-segmented, having two pairs of functional swimming legs, the third being rudimentary. Posterior corner of the last metasomal segment rounded. Urosome 2-segmented. Antennule 12-segmented. Antenna, feeding appendages well developed and similar to those of adult.



Figs. 31–37. Postnaupliar developmental stages of *L. tasmanica* sp. nov. 31, Right antennule, copepodid stage I; 32, right antennule, copepodid stage II; 33, right antennule, copepodid stage III; 34, right antennule, female, copepodid stage IV; 35, right antennule, male, copepodid stage IV; 36, right antennule, female, copepodid stage V; 37, right antennule, male, copepodid stage V.

(Copepodid Stage II—Figs 21, 32, 39, 44, 49, 54, 59, 64, 69 and 73)

Body length between 0·85 and 1·00 mm (based on 4 specimens). Sexes indistinguishable. Rostrum and dorsal cuticular lenses well developed. Metasome 4-segmented with three pairs of functional swimming legs, the fourth being rudimentary. Posterior corner of the last metasomal segment rounded. Urosome 2-segmented. Antennule 15-segmented. Antenna and feeding appendages well developed and similar to those of adult.

(Copepodid Stage III—Figs 22, 33, 40, 45, 50, 55, 60, 65, 70, 74 and 77)

Body length between 1·20 and 1·35 mm (based on 17 specimens). Sexes indistinguishable. Rostrum and dorsal cuticular lenses well developed. Metasome 4-segmented having four pairs of functional swimming legs, the fifth being rudimentary. Posterior corner of the last metasomal segment rounded. Urosome 2-segmented. Antennule 19-segmented. Antenna and feeding appendages well developed and similar to those of adult.

(Copepodid Stage IV—Figs 23, 24, 27, 28, 34, 35, 41, 46, 51, 56, 61, 66, 71, 75 and 78)

Sexes can be easily distinguished at this stage by the antennule and the fifth pair of swimming legs.

Female. Body length between 1·70 and 1·73 mm (based on 4 specimens). Rostrum and dorsal cuticular lenses well developed. Metasome 5-segmented as in adult form, however, the last segment ending as a blunt point; bears five pairs of functional swimming legs with the fifth being modified. Urosome 3-segmented. Antennule symmetrical, 20-segmented. Antenna and feeding appendages essentially of the adult form. Although a complete set of swimming legs present, the setation and segmentation of first to fourth swimming legs incomplete. Fifth legs modified, symmetrical, biramous and of one segment.

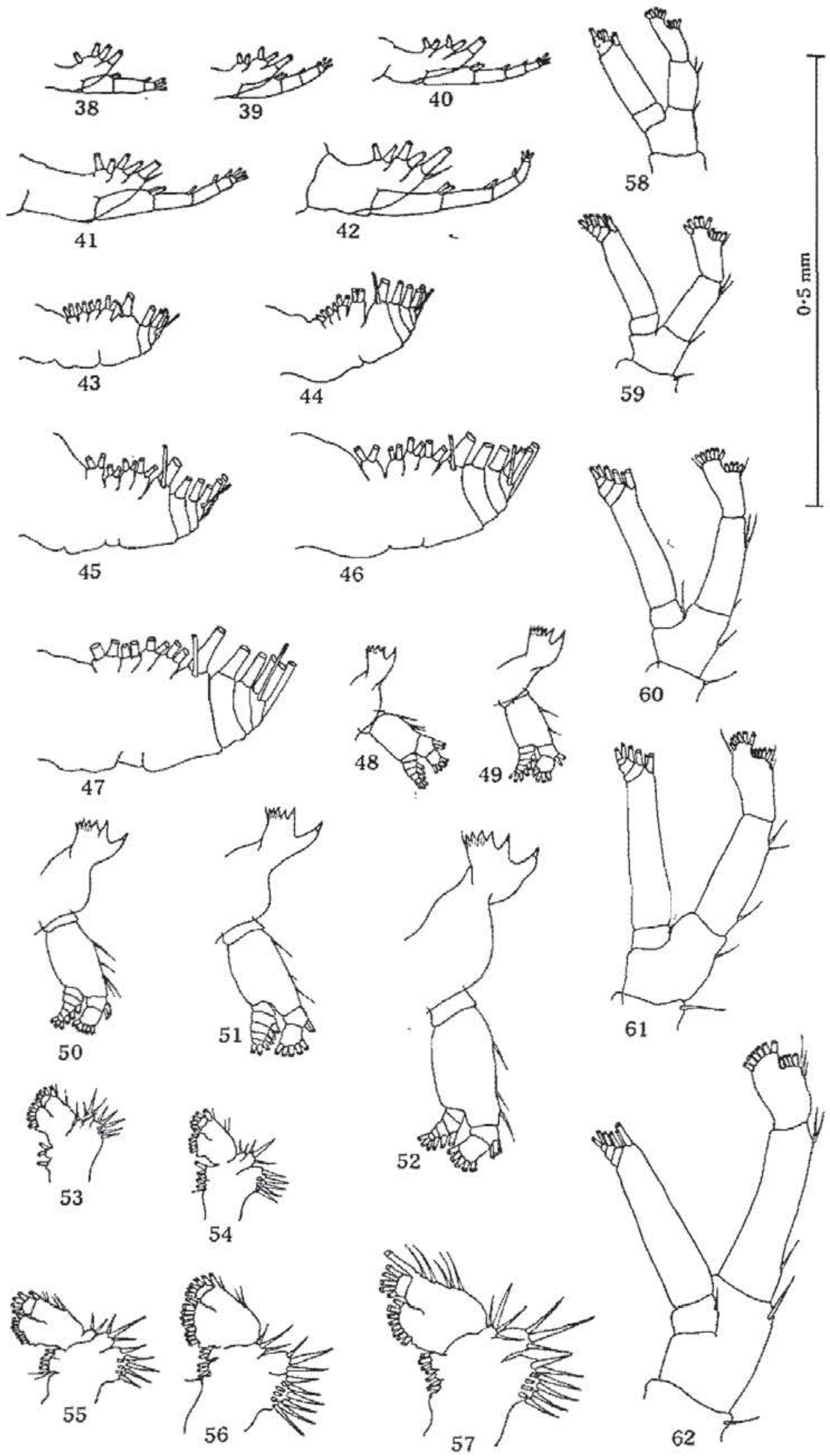
Male. Body length between 1·55 and 1·71 mm (based on 4 specimens). Metasome, urosome, antennule, feeding appendages and 1st to 4th swimming legs identical in structure with those of female. Antennule asymmetrical, 20-segmented, the right being slightly modified (a slight swelling at the segments 9, 10 and 11 occurs at the right antennule). Fifth legs modified, asymmetrical, biramous and of one segment. The right leg slightly larger and longer than the left.

(Copepodid Stage V—Figs 25, 26, 29, 30, 36, 37, 42, 47, 52, 57, 62, 67, 72, 76 and 79)

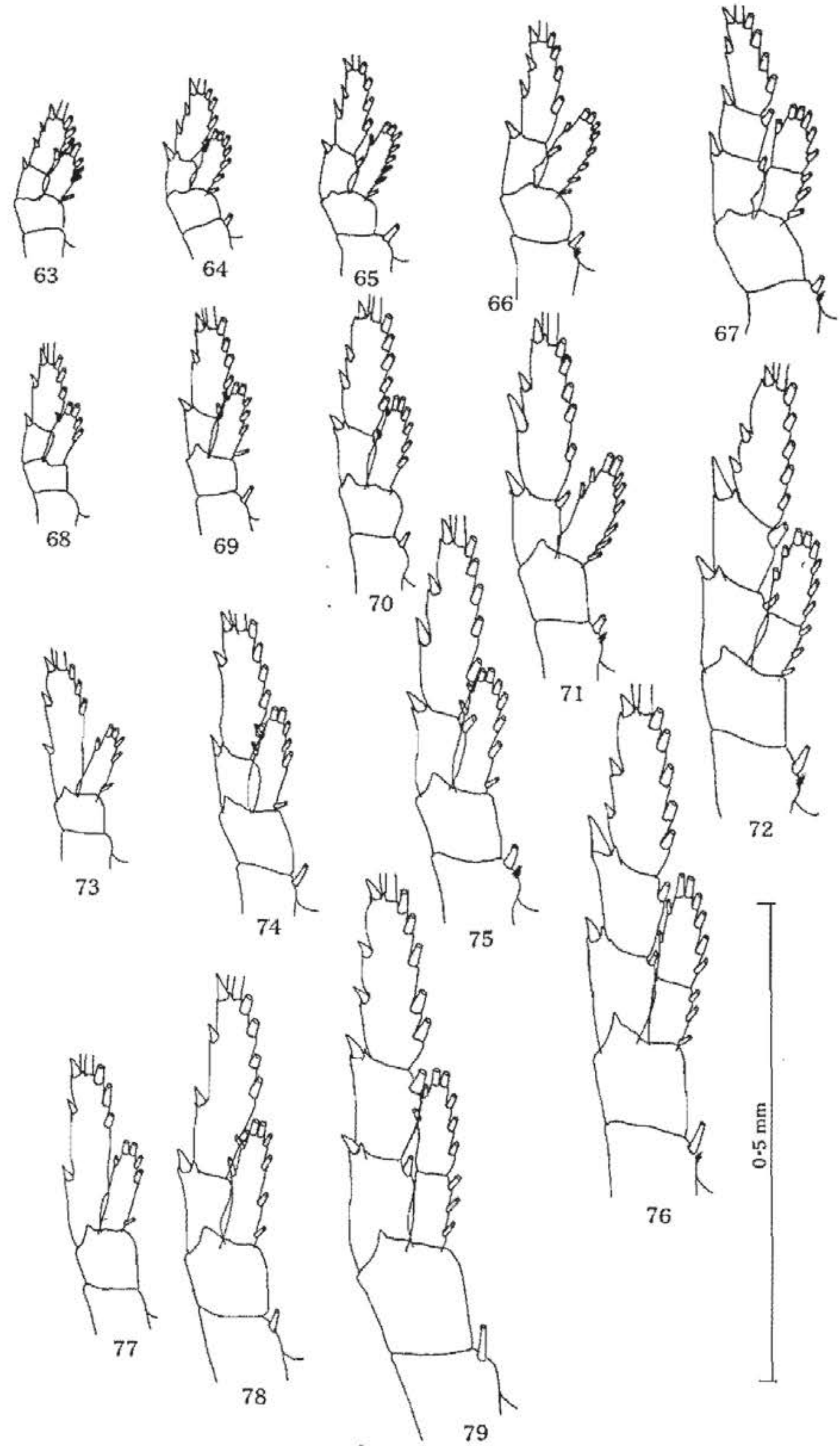
Sexes are easily distinguishable at this stage by the antennule, the number of urosomal segments and the structure of the fifth pair of modified swimming legs.

Female. Body length between 2·08 and 2·18 mm (based on 3 specimens). Metasome, dorsal cuticular lenses, antenna, and feeding appendages are essentially of the adult form. Urosome symmetrical, lacking triangular processes on the first urosomal segment, and 3-segmented. Antennule symmetrical, 21-segmented. The setation and segmentation of swimming legs 1–4 identical with that in the adult. Fifth pair of legs symmetrical, biramous and similar in structure to the adult female fifth legs; however, it can be easily distinguished by the two small spines on the outer margin of exopod and by the smooth round endopod.

Male. Body length between 2·00 and 2·10 mm (based on 4 specimens). Metasome, dorsal cuticular lenses, antenna, feeding appendages and swimming legs 1–4 are identical with those of female. Urosome 4-segmented and symmetrical. Antennule asymmetrical, the right being modified, 21-segmented. Distinct expansion of segments 9–12 can be seen on the right antennule; however, at this stage there is no indication of closely spaced denticles which are obvious in the adult male. Fifth pair of legs highly asymmetrical, the right being larger and longer. Endopods are in a form of buds. Exopods 2-segmented.



Figs. 38–62. Postnaupliar developmental stages of *L. tasmanica* sp. nov. 38–42, Maxilliped, copepodid stages I–V; 43–47, second maxilla, copepodid stages I–V; 48–52, mandible and palp, copepodid stages I–V; 53–57, first maxilla copepodid stages I–V; 58–62, antenna, copepodid stages I–V.



Figs. 63–79. Postnaupliar developmental stages of *L. tasmanica* sp. nov. 63–67, First swimming legs, copepodid stages I–V; 68–72, second swimming legs, copepodid stages I–V; 73–76, third swimming legs, copepodid stages II–V; 77–79, fourth swimming legs, copepodid stages III–V.

Discussion

The adult female of the present species can be distinguished from those of the 52 species and subspecies of this genus described to date by the form of genital segment which has a small triangular process each on either side of the anterior region. The fifth pair of legs are similar to those of *L. fluviatilis* (Dahl 1894), but differ in that the present species has three blunt forked processes at the distal region and having a long and slender endopod being at least 3·5 times as long as its maximum width, whereas *L. fluviatilis* has only two blunt forked processes at the distal region and has a stout endopod which is about 2·5 times as long as its maximum width.

The adult females of *L. cervi* Kramer 1894 and *L. caudata* Nicholls 1944, both of which have been recorded from southern Australian waters, differ distinctly from *L. tasmanica* sp. nov. in features of last metasomal segment, urosome and the 5th legs in the former and urosome and the 5th legs in the latter species.

Table 1. Comparison of the males of *Labidocera* species

	L. tasmanica	*L. detruncatum*	*L. madurae*	*L. euchaeta*	*L. sinilobata*	*L. cervi*
Proximal expansion on the inner distal segment of the right fifth leg	Present and serrated	Absent	Absent	Absent	Absent	Absent
Process on the 3rd last segment of right antennule	Present finger-like	Absent	Absent	Present spine-like	Present finger-like	Present spine-like
Distinct protuberance at the inner distal region of the left fifth leg	Absent	Absent	Absent	Present	Present	Absent
Distal spines on the distal segment of left fifth leg	Three, outer the longest	Three, middle the longest	As in *L. detruncatum*	Three, thin, long, and of equal length	Two, thin, long, and of equal length	Five, small, second from outer the longest

The adult male of the present species differs from the male of all other known species of this genus in having an inner proximal portion of the distal segment of the right 5th leg expanded and serrated. It is comparable with the following species: *L. detruncatum* (Dana), Sydney variety described by Dakin and Colefax (1940); *L. madurae* A. Scott 1909; *L. euchaeta* Giesbrecht, dimorphic form 1 described by Sewell (1912); *L. sinilobata* Shen and Lee 1963; *L. cervi* Kramer 1894. These species are compared with *L. tasmanica* sp. nov. in Table 1.

There have been a number of studies of the development and life histories of marine copepoda: for example, Lebour 1916 and Marshall and Orr (1955) on *Calanus finmarchicus*; Campbell (1934) on *Calanus tonsus* and *Euchaeta japonica*; Johnson (1934) on *Tortanus discaudatus*; Johnson (1935) on *Labidocera trispinosa* and *L. jollae*; Heron and Bowman (1971) on *Clausocalanus laticeps, C. brevipes* and *Ctenocalanus citer*; Lawson and Grice (1973) on *Paracalanus crassirostris*.

The basic postnaupliar developmental stages of *L. tasmanica* sp. nov. are very similar to the postnaupliar developmental stages of calanoids so far described and are comparable to the postnaupliar developmental stages of *L. trispinosa* and *L. jollae* described by Johnson (1935). Apart from the specific characters of the new species, the main feature in which it differs from *L. trispinosa* and *L. jollae* is the form of antennule of the copepodid stage IV. In the present species sexes can be distinguished not only by the form of the fifth pair of legs but also by the right antennule which in the male is swollen slightly from segments 9 to 11. This slight swelling was not mentioned in *L. trispinosa* and *L. jollae* by Johnson (1935). The features by which the postnaupliar developmental stages of *L. tasmanica* sp. nov. can be identified are set out in Table 2.

Table 2. Identification table for copepodid stages of *Labidocera tasmanica* sp. nov.

Copepodid stages:	I	II	III	IV	V	VI (Adult)
Total length (mm)	0·78–0·79 (3)[A]	0·85–1·00 (4)	1·20–1·35 (17)	1·70–1·73 females (4) 1·55–1·71 males (4)	2·08–2·18 females (3) 2·00–2·10 males (4)	2·63–3·35 females (11) 2·45–2·83 males (12)
Rostrum	Absent	Present	Present	Present	Present	Present
Dorsal cuticular lenses	Poorly developed	Well developed	Well developed	Well developed	Well developed	Well developed[B]
No. of metasomal segments	3	4	4	5	5	5
No. of urosomal segments	2	2	2	3, female 3, male	3, female 4, male	2, female 4, male
Antennule and no. of free segments	Symmetrical 12	Symmetrical 15	Symmetrical 19	Symmetrical 20, female Asymmetrical 20, male	Symmetrical 21, female Asymmetrical 21, male	Symmetrical 23, female Asymmetrical 24 left, 19 right
No. of legs present	1st and 2nd (3rd rud.)[C]	1st, 2nd and 3rd (4th rud.)	1st, 2nd, 3rd, and 4th (5th rud.)	1st, 2nd, 3rd, 4th and 5th[D]	1st, 2nd, 3rd, 4th and 5th[D]	1st, 2nd, 3rd, 4th and 5th[E]

[A] No. of specimens in parentheses. [B] Male lenses larger than those of female. [C] Rudimentary. [D] Modified—symmetrical in female, asymmetrical in male. [E] Modified—symmetrical in female; asymmetrical in male, right subchelate.

Acknowledgments

I would like to thank the following who made this work possible: Dr E. R. Guiler and Dr J. L. Hickman for their encouragement and critically examination of the manuscript; Professor B. Johnson for his encouragement and keen interest in the work; the Captain of the Zoology Department Research Vessel *Neotrigonia*; Mr T. Sward, for his help in the field; Mr D. J. Tranter and Mr F. B. Griffith of the Division of Fisheries and Oceanography, CSIRO, Cronulla, for examining the specimens and helpful suggestions.

This work has been carried out while the author held a Colombo Plan Fellowship, for which he is grateful.

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Manuscript received 4 February 1974

Supporting Paper No. 2

A New Species of *Sagitta* (Chaetognatha) from D'Entrecasteaux Channel, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 1975, 109:77-83 (in press)

A NEW SPECIES OF SAGITTA (CHAETOGNATHA)
FROM D'ENTRECASTEAUX CHANNEL, TASMANIA.

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Abstract

A new species of the genus *Sagitta* (Chaetognatha), *S. guileri* sp. nov. found in D'Entrecasteaux Channel, Tasmania, is described and figured. Its relation to *S. neglecta* Aida is discussed and its distribution in the south-east coastal waters of Tasmania is given.

Introduction

During a study of the zooplankton of the south-east coastal waters of Tasmania, an abundance of specimens of a species of *Sagitta* were collected in the northern parts of D'Entrecasteaux Channel, Southern Tasmania. These specimens differed from all known species and are considered to represent a new species for which the name *Sagitta guileri** sp. nov. is proposed.

Description

Sagitta guileri sp. nov.

(Figs. 1a-g)

Type Material

Holotype, paratypes 10; Tasmanian Museum Registration Nos. K762 - K763. Taken in a midwater (10m) plankton tow during

* In honour of Dr. E.R. Guiler, Reader in Zoology, University of Tasmania.

the night of 22nd. December, 1971, off Barnes Bay, Bruny Island, D'Entrecasteaux Channel, Tasmania.

Description

Body Length, 8.0 - 10.5mm based on 25 mature (stage IV) specimens.

Body rigid and opaque in formalin preserved specimens. Length of fully mature (Stage IV) specimens reaches to 10.5mm. Head is of normal size, approximately equal to the widest region (mid region) of the body. Hooks totally concealed if viewed from dorsal side of head. Eyes rounded with the pigmented area well developed and in the form of letter 'T' lying sideways with the top part pointing laterally. Intestinal diverticulum present but not obvious. Corona ciliata absent.

Tail region forms between 25.5 and 29.6% of the total body length (excluding the tail fin). The number of hooks may be 6 or 7. The number of anterior teeth is either 4 or 5. There are between 6 to 9 posterior teeth.

Collarette present, extending from head to tail region as far as middle region of the tail fin; relatively thicker at the neck and the vicinity of seminal vesicles.

Anterior fin begins at a distance (approximately 4.0% of the body length) behind posterior end of ventral ganglion, elliptical in shape shorter than posterior fin with the widest part at the middle region; entirely supported by rays.

Posterior fin long and situated more on tail region than on the body; completely supported by rays; posterior end terminates just in front of anterior tip of seminal vesicles.

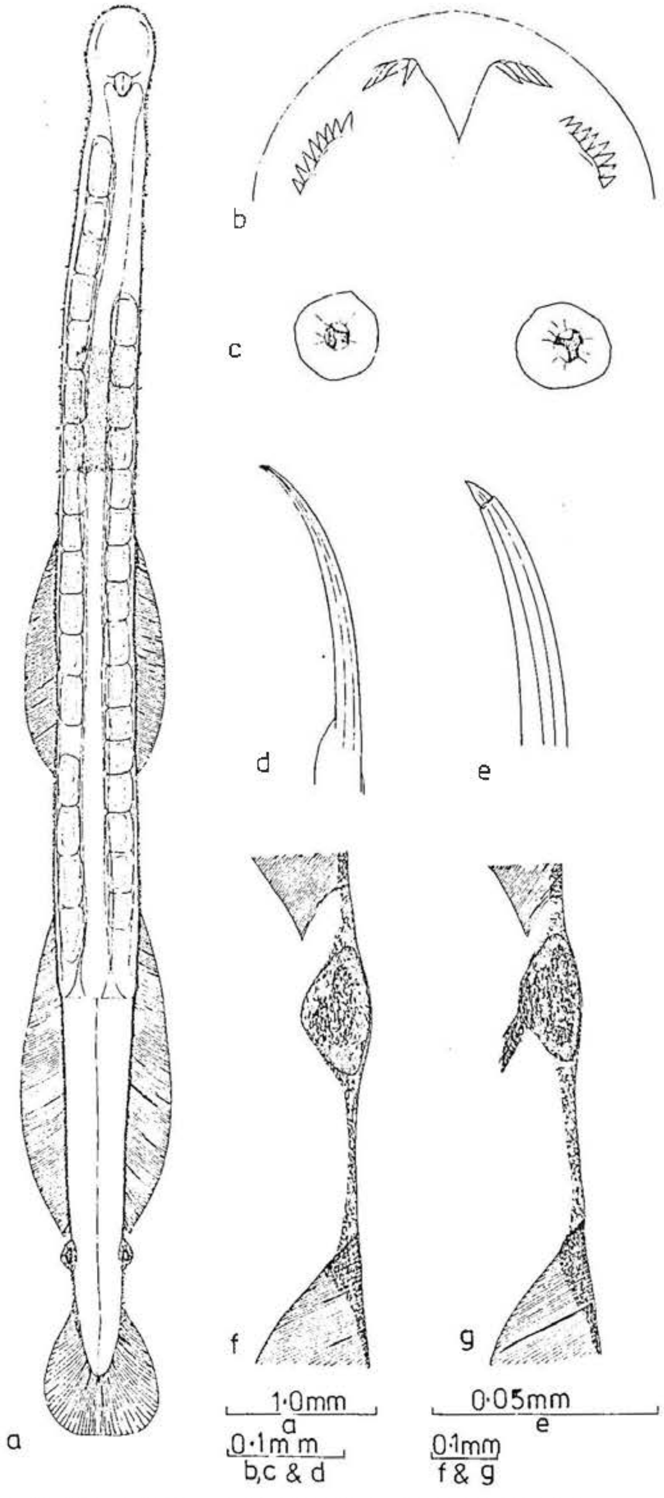

Figure 1. Sagitta guileri sp. nov. a, Entire animal; b, ventral view of anterior region of the head showing anterior and posterior teeth; c, detailed structure of eyes; d, detailed structure of 3rd right hook; e, detailed structure of distal region of 3rd right hook; f, mature seminal vesicle; g, mature seminal vesicle (bursting).

Ovaries long one on each side reaching up into the neck region. Ova rounded and large, in one row, filling the body cavity.

Seminal vesicles situated near posterior fin; roundish to triangular in shape with the protuberance at the mid-lateral region; bursting at the protuberance (mid-lateral edge) when mature.

Distribution

S. sp. nov. was very abundant in the Northern parts of D'Entrecasteaux Channel. The maximum number collected in a tow was 1005 (72.9 specimens per cubic meter). It was captured usually during night tows and found to be abundant from November to January. During the remaining months the number observed was low (less than 1.2 cubic meter).

A large number of inshore and offshore coastal zooplankton samples have been studied, however, S. guileri sp. nov. was found only in the inshore waters. The localities of zooplankton stations sampled and those where S. guileri sp. nov. was encountered are shown in Fig. 2.

Discussion

Sagitta guileri sp. nov. belongs to the 'neglecta' group (Tokioka and Pathansali, 1963; Alvarino, 1967) and is most closely related to S. neglecta Aida. The main characters in which it can be distinguished from S. neglecta are;

i) low number of posterior teeth,

ii) position of anterior fin in relation to ventral ganglion,

iii) extended length of ovaries,

iv) shape of seminal vesicles.

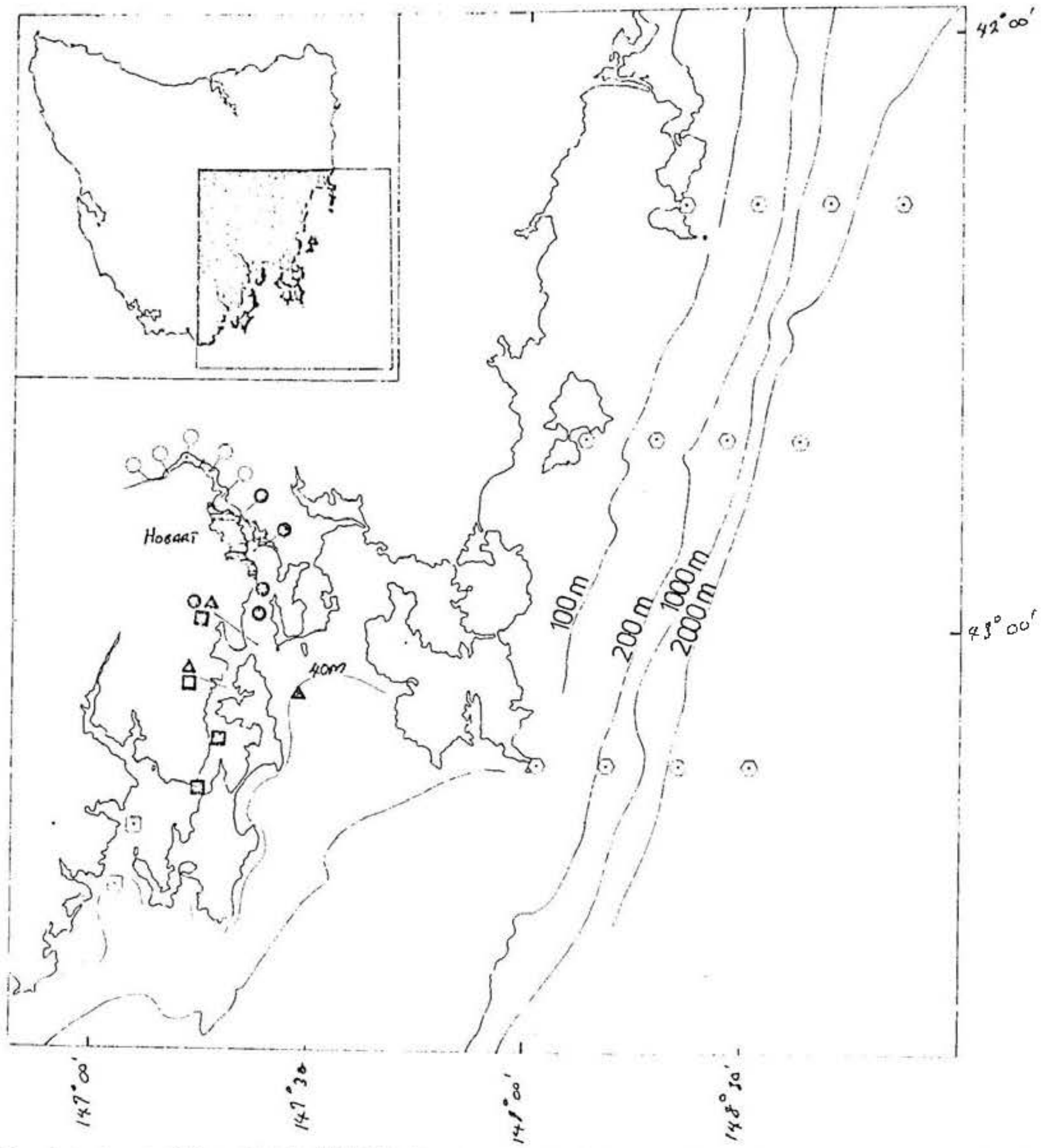

Figure 2. Zooplankton stations in the south-east coastal waters of Tasmania. (○ indicates day stations; samples taken over a period of 2 years-June 1971 to May 1973-during which a total of 10 cruises were made approximately 1 to 3 months apart: △ indicates day and night stations; sampled once a month for a period of a year-August 1971 to July 1972: □ indicates day stations; sampled once every 2 months for a period of a year-August 1972 to July 1973: ○ indicates day stations; sampled during 2 cruises-October 1973 and April 1973: Solid symbols indicates stations where S. guileri sp. nov. was found. Open symbols indicates where S. guileri sp. nov. was not found.)

Table 1. Comparison of S. ruileri sp. nov. with S. neglecta Aida.

	S. ruileri sp. nov.	S. neglecta Aida: Alvarino (1967)	S. neglecta Aida: Thomson (194	S. neglecta Aida: Tokioka (1959)	S. neglecta Aida: Sund (1959)	S. neglecta Aida: Michael (1919)	S. neglecta Aida: Michael (1911)
Total Length (mm)	8-10.5	8.0	8 - 10	6.8 - 8.1	7.3	6.5 - 8	7.9 - 12
Body	Opaque and strongly built	Firm, rigid, opaque with strong muscles.	-	-	Firm, semi-opaque.	-	Firm, rigid, retaining its form well.
Head	Normal size, about or less than the widest part of the body.	Regular or small.	-	-	-	-	-
Eyes	Rounded, pigmented area strong, dark and in the form of a 'T' lying sideways with top part pointing laterally.	Roundish; pigmented area shaped like a five pointed star with three large ares and two small.	-	-	-	-	-
Intestinal diverticulum	Present	Appear at the anterior end of the digestive tract.	-	-	Present	-	-
Corona ciliata	Absent (5% formalin preserved specimens).	Clearly visible, and it extends in a weaving pattern from a location between the eyes to midway from neck to ventral ganglion.	-	-	-	-	-
Tail %	25.5 - 29.6	26 - 30	27 - 32	28 - 32.4	27 - 31 (27.4)	30 - 33.5	26 - 30
Hooks	6 - 7	6 - 7	6 - 8	6 - 8	6 - 8 (7)	6 - 7	7 - 9
Anterior Teeth	4 - 5	7	5 - 7	5 - 8	5 - 7 (5)	4 - 8	3 - 5
Posterior Teeth	6 - 9	up to 18	9 - 16	13 - 18	13 - 17 (17)	12 - 16	8 - 11
Collarette	Present, extending from head to tail as far as middle region of tail fin. Relatively thicker at the neck and vicinity of seminal vesicle.	Filling neck region to anterior fins and as a thin layer to tip of tail.	-	-	Present	-	Extends from neck region to well towards, but never reaches the ventral ganglion.
Anterior fin	Beginning at a distance (approximately 4.0% of the body length) behind ventral ganglion. Shorter than posterior fin and completely rayed.	Beginning a short distance behind posterior end of ventral ganglion; shorter than posterior fin; no rayless zone present.	-	-	Starts at ventral ganglion.	Three specimens out of 10 specimens studied had the anterior fin beginning 1.0 to 1.5% of the body length behind ventral ganglion. Remaining specimens begin at ventral ganglion.	Shorter and narrower than posterior fin. Extends to posterior end of ventral ganglion. In form it is narrowly and acutely triangular.
Posterior fin	Long and elliptical in shape; more on the tail region. Posterior end terminates just in front of anterior tip of seminal vesicles. Completely rayed.	Beginning at a short distance behind anterior fins; extending to seminal vesicles; elliptical in shape; located more on tail (2/3 of their length) than trunk; no rayless zone.	-	-	Reaches seminal vesicle.	Posterior end touching seminal vesicle.	Extends nearly, if not quite to seminal vesicle when seminal vesicles are timid. Half elliptical in form.
Ovaries	Long, reaching up into the neck region (one on each side). Ova rounded and large in one row; filling the body cavity.	Wide tubes filling trunk cavity and reaching up to midway between neck and ventral ganglion; ova round, large and arranged in one row.	-	-	Containing round ova, extending anterior to posterior border of anterior fin.	-	-
Seminal vesicles	Roundish to triangular in shape; protuberance at the mid-lateral edge; bursts at the mid-lateral edge when mature. Nearer to posterior fin.	Touching end of posterior fins, apart from tail fin; distance of seminal vesicles to tail fin is about equal length of vesicles; roundish with anterior part more voluminous, with a protuberance at anterior end at the base of which a fission line is visible; bursting along that line extending towards lateral edge of dorsal side to posterior end of vesicles.	-	-	Rounded	-	The seminal vesicles do not present such decided contrast as in S. serratodentata.

anterior fin begins approximately 4.0% of the body length behind the ventral ganglion.

The structure of ovaries and ova of S. guileri sp. nov. is similar to that of S. neglecta described by Alvarino (1967). However, in S. neglecta the ovaries reach up to midway between the neck and ventral ganglion whereas in S. guileri sp. nov. they extend into the neck region.

The seminal vesicles of S. guileri sp. nov. differ from those of S. neglecta in shape (see Table 1). The shape of the seminal vesicles of S. neglecta has been described by Alvarino and as claimed by Michael (1911) is similar to that of the seminal vesicles of S.serratodentata.

The relationship of S. guileri sp. nov. to material from South eastern Australia recorded (Thomson, 1947) as S. neglecta is not clear (Table 1). However, Professor Thomson, after examining material of the new species has expressed the opinion (personal communication) that "a careful comparison of S. guileri sp. nov. and recognised S. neglecta from Port Hacking may well suggest consistent differences." (Unfortunately an attempt to obtain samples of this material for comparison with that described herein was unsuccessful.).

Acknowledgements

Sincere thanks are due to the following: Dr. E.R. Guiler and Dr. J.L. Hickman for their encouragement and critically examining the manuscript; the skipper of the Zoology Department Research Vessel, "Neotrigonia", Mr. T. Sward, for his help in the field; Professor J.M. Thomson, Head of Zoology Department, University of Queensland, for examining the specimens and helpful comments; Mr. F.B. Griffith, Curator of Zooplankton, Division of Fisheries and Oceanography, C.S.I.R.O., Cronulla, for examining the specimens.

This work has been carried out while the Author held a Colombo Plan Fellowship for which he is grateful.

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Supporting Paper No. 3

Relative Composition of Zooplankton Groups as an Indication of Water Movement in the Inshore Coastal Waters of South-east Tasmania. Search , 1975, 6(11-12): (in press)

RELATIVE COMPOSITION OF ZOOPLANKTON GROUPS AS AN INDICATION OF WATER MOVEMENT IN THE INSHORE COASTAL WATERS OF SOUTH-EAST TASMANIA.

Nyan Taw*

(Abstract - Relative composition of indicative zooplankton species groups (inshore coastal, coastal and oceanic) are used to determine the influence of estuarine and the intrusion of oceanic and coastal waters in the South-east inshore coastal waters of Tasmania. The result indicates that estuarine influence extended into the coastal area during September and November; the oceanic influence was pronounced in January and February. The possible effects of movement of waters on the accumulation of heavy metals in oysters found in the Derwent Estuary and adjacent waters are discussed.)

The presence of species of oceanic copepods in coastal waters has been used as an indicator of the intrusion of oceanic waters into coastal areas as at Georges Bank, Gulf of Maine (Colton, Temple and Honey, 1962). Jeffries (1962) showed that the indicator species concept can be also applied to estuarine circulation over a range of as little as a mile or so.

Comparative studies on the seasonal and diurnal vertical variation in occurrence and abundance of zooplankton in inshore coastal waters (Storm Bay, mouth of Derwent River and the northern part of D'Entrecasteaux Channel) of south-east Tasmania revealed a large number of individuals of some species of oceanic zooplankton from time to time. This suggests an invasion of oceanic waters into the coastal areas. Two other species of zooplankton were found to be restricted to the mouth of Derwent River and

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D'entrecasteaux Channel waters; only on two occasions were they found in Storm Bay, which suggested that Storm Bay is normally coastal, with only occasional estuarine influence as well.

According to figures released by the Department of Environment in reports to the Tasmanian Parliament in 1972 and 1973, there were high levels of heavy metals in Derwent River waters. Abnormally high concentration of heavy metals (zinc, cadmium and copper), which would be lethal to human consumption, were found in oysters from Ralph's Bay and from Pipe Clay Lagoon, Frederick Henry Bay (Thrower and Eustace, 1973a, 1973b). Eustace (1974) found that shellfish from Derwent River have the ability to accumulate certain metals to abnormally high levels, but that this was not the case with fin-fishes. The source of these heavy-metal concentrations in molluscs found in the Derwent River and adjacent waters would be industrial waste discharge and domestic sewage. The accumulation of heavy metals in Derwent River waters and their distribution outside the estuary would depend on tidal movements and current flows (oceanic and coastal currents as well as freshwater flow).

The relative abundances of indicative zooplankton species groups were used to determine such influences. The usual method of identifying water masses using a few specific indicator species (Russell, 1939; Fraser, 1952; Bary, 1959; Shead, 1965; and Muller, 1972) was not possible due to the complexity of the marine environment. (An indicator species group as normally defined is a group of species so characteristic of a particular biotope that occasional records within the normal

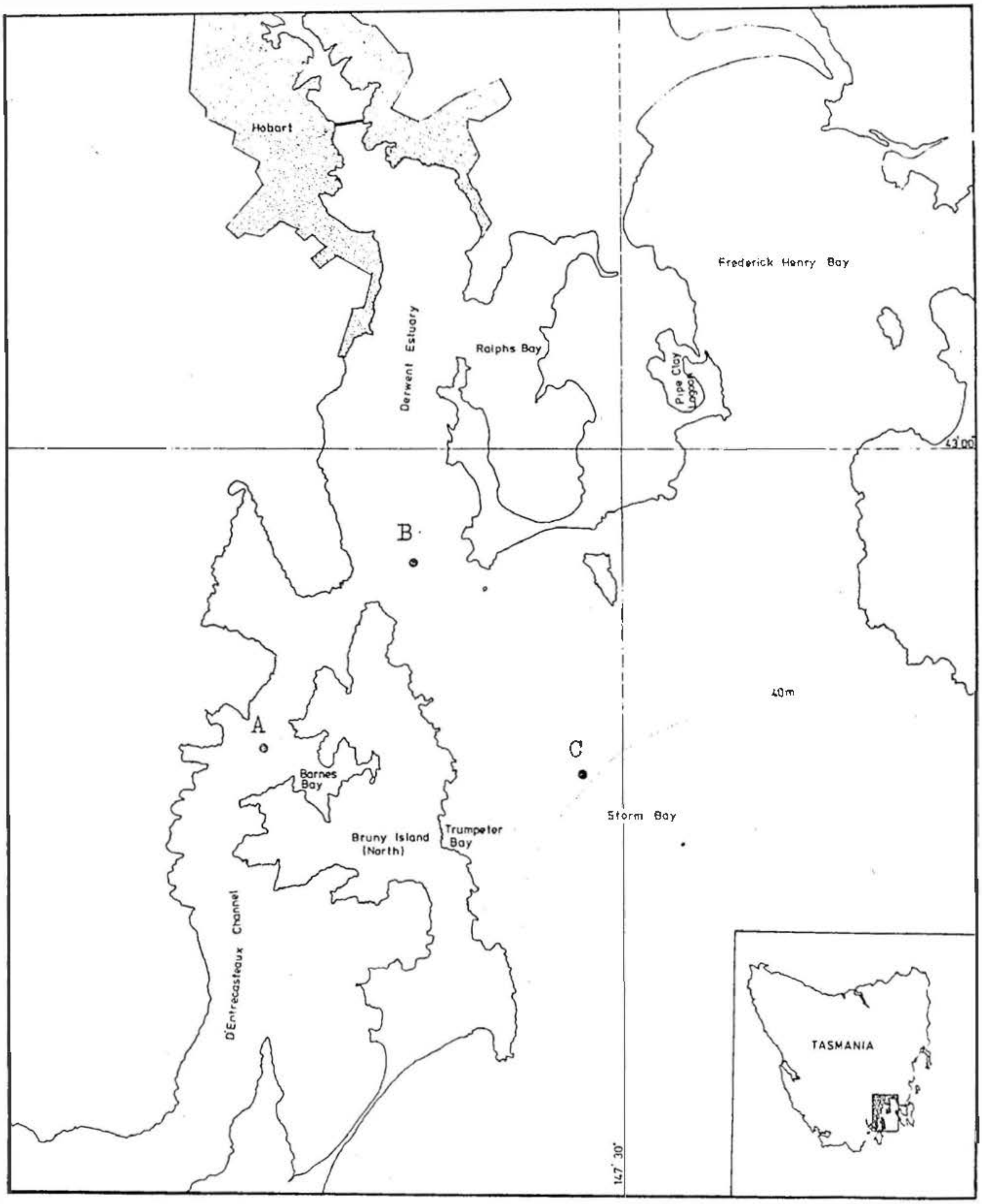

Figure 1. The location of Stations A, B and C in relation to Storm Bay and the Derwent River.

geographic range of another are taken to indicate physical translocation of one biotope relative to the other.) Offshore areas east of Tasmania are influenced by both warm, high salinity sub-tropical and cold, low salinity sub-antarctic waters, a result of the Sub-tropical Convergence moving north and south in accordance with season (Wyrtki, 1960). In addition, freshwater runoff from the Derwent River is also seasonal.

The data used were averages of six day and night zooplankton samples (three tows - surface, 10 and 20m - during the day, and three tows at the same depths at night) collected and counted once every month at each of the three Stations A, B and C (Fig. 1). These stations were selected to sample Channel, Derwent and Storm Bay plankton.

Dominant indigenous coastal species such as Paracalanus parvus and Acartia clausi were excluded in order to emphasize the occurrence of the more unusual forms. Species considered were classified according to their previous habitat records, namely, i) inshore coastal, ii) coastal, iii) oceanic (Table 1). The proportions of the three species groups were then determined (Fig. 2). The pattern of inshore coastal, coastal and oceanic influences implied by these observations was examined in the context of records of freshwater flow from the Derwent River, and seasonal depth profiles of salinity at the stations (Fig. 3).

In general, Stations A and B can be considered as having a similar fauna, differing considerably from that at Station C, as is shown by the proportions of inshore species at the three stations throughout most of the year. The presence of this group at Station C in September and November was associated with

TABLE 1

Zooplankton Indicator Species Groups

Inshore Coastal Species Group	Coastal Species Group	Oceanic Species Group
* *Sagitta guileri* Nyan Taw	* *Calanus australis* Brodsky	* *Calanus tonsus* (Copepodid Stage V)
Pseudodiaptomus cornutus Nicholls	* *Centropages australiensis* Fairbridge	* *Clausocalanus ingens* Frost & Fleminger
	Labidocera tasmanica Nyan Taw	* *Sagitta serratodentata* Krohn
		* *Sagitta minima* Grassi
		* *Salpa fusiformis* Cuvier
		Calanus tenuicornis Dana
		Calanoides carinatus (Kroyer)
		Calocalanus pavo (Dana)
		Calocalanus styliremis Giesbrecht
		Calocalanus tenuis Farran
		Leptocalanus plumulosus (Claus)
		Clausocalanus arcuicornis (Dana)
		Clausocalanus mastigophorus (Claus)
		Clausocalanus jobei Frost & Fleminger
		Clausocalanus paraperqens Frost & Fleminger
		Euchirella rostrata (Claus)
		Metridia lucens Giesbrecht
		Pleuromamma abdominalis (Lubbock)
		Pleuromamma gracilis (Claus)
		Lucicutia flavicornis (Claus)
		Candacia spp.
		Heterorhabdus papilliger (Claus)
		Scolecithrix danae Lubbock
		Acartia danae Giesbrecht
		Racovitzanus sp.
		Oncaea venusta Phillippi

* Major contributors in the group.

a high freshwater flow from the Derwent River, recorded by a maintaining station upstream at Macquarie Plains from August to November (monthly average 4768 - 7359 cusecs from August to November; monthly average 1865 - 2664 cusecs in the remaining months, except in July when an average of 5854 cusecs was recorded). A pronounced stratification of the water column, with low-salinity surface water observed from September to December at Stations A and B and in November and December at Station C (Fig. 3), is consistent with the view that, at times of high-volume river flow, fresh water from the Derwent has a seasonal influence on the environment in Storm Bay.

Oceanic influence also was noted at Station C in August, as indicated by the presence of 90.3% of oceanic species in the plankton. Substantial influence of oceanic waters was detected again at this station in December, the proportion of oceanic species finally reaching 97.0% in January. At Station B substantial oceanic water influence (22.9% of oceanic species) was first encountered in December, reaching a maximum of 93.4% of oceanic species in February and extending at that time into Station A area (95.1% of oceanic species). Sub-surface high salinities at Stations B and C in December were further evidence of oceanic influence. From March to June, waters at Station C were coastal in nature, with only 1.5-15.9% of oceanic species and no inshore coastal species being found. In July, 59.5% of oceanic species was recorded at Station C, indicating a return of oceanic waters, while Stations A and B yielded low or negligible percentages of oceanic species during this month, probably due to the high freshwater runoff in the Derwent. The appearance of oceanic influence at Station C in July as indicated by oceanic species was in agreement with the subsurface high

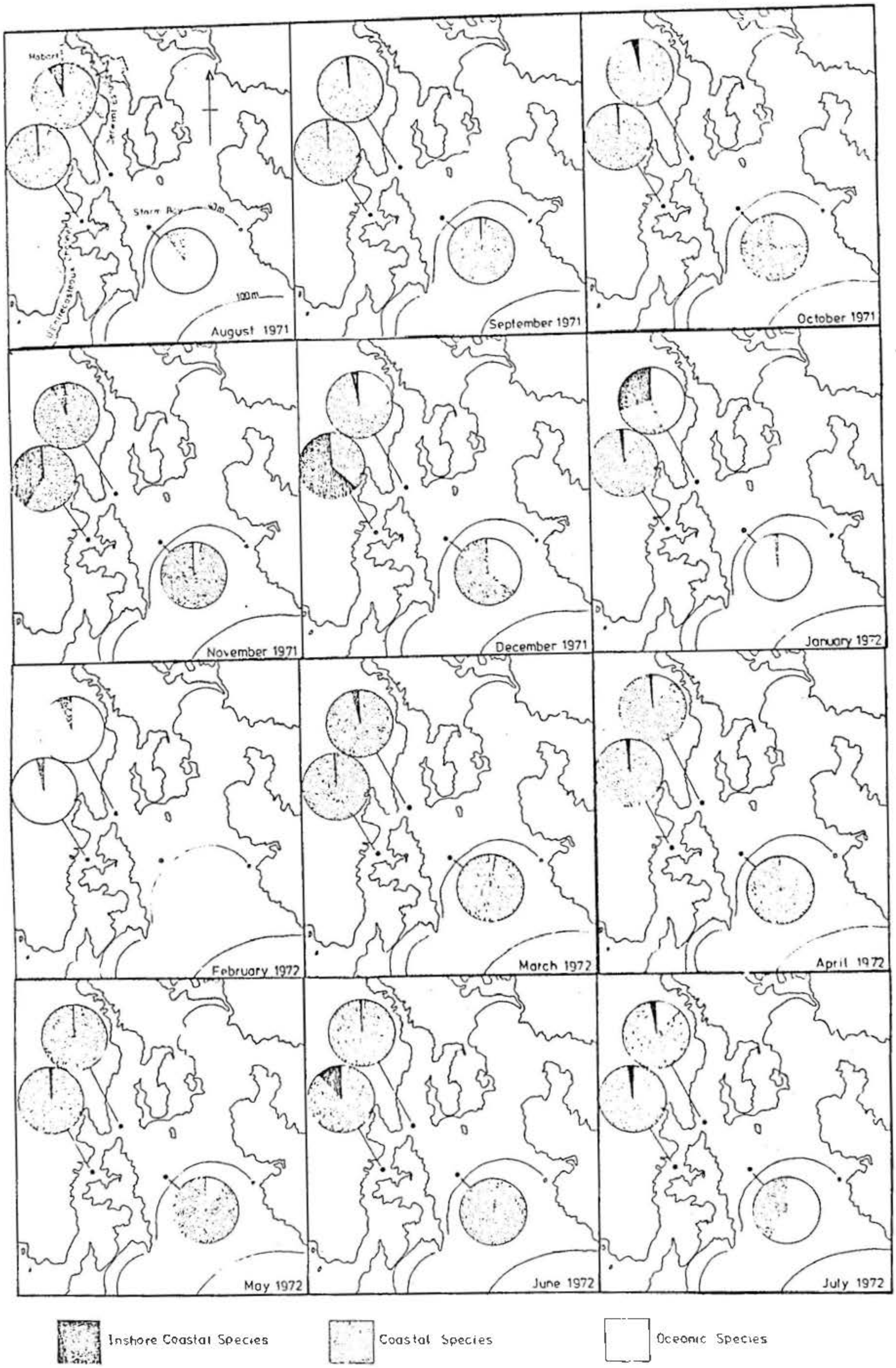

Figure 2. Seasonal composition of zooplankton species groups at Stations A, B and C.

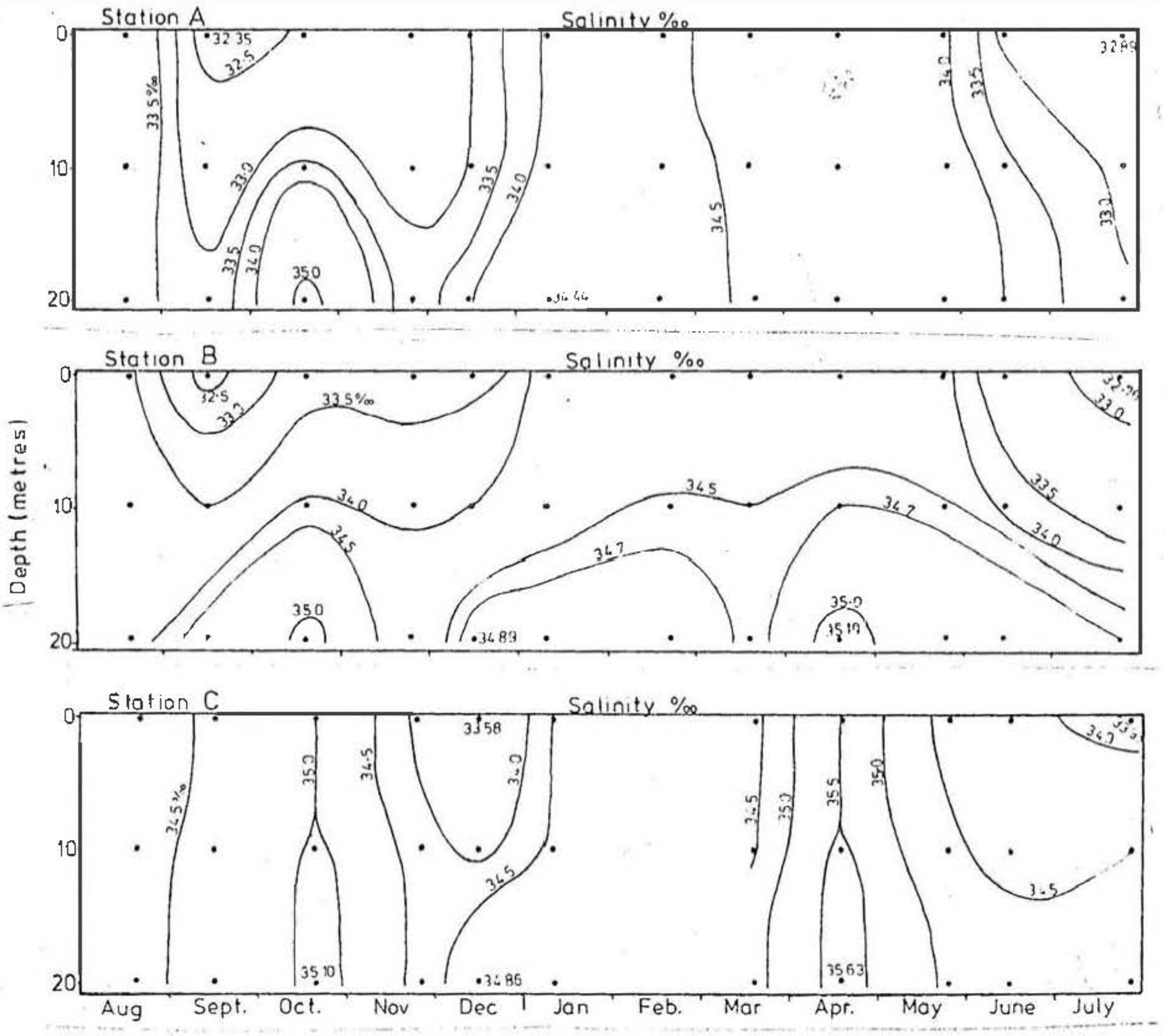

Figure 3. Seasonal depth profile of salinity at Stations A, B and C. (black dots indicate points from which samples were taken)

salinities recorded at the Station during the month.

The evidence both of indicative zooplankton species groups and of the salinity profile indicates that the study area, although normally inshore-coastal and coastal in nature, was occasionally influenced by both estuarine and oceanic waters. Thus, if an influx of oceanic water occurs it may affect the outflow of the Derwent in two possible ways. If the flow is counterclockwise, it may wash the Derwent waters down the Channel, or, if clockwise, into adjacent bays. The influence of the known heavy-metal pollution thus may not be confined to the Derwent itself.

Acknowledgements

I wish to thank Dr. E.R. Guiler for his encouragement and critically reading the manuscript and also Mr. Tas Sward, the skipper of the Zoology Department Research Vessel "Neotrigonia", for his help in the field.

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